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Precambrian Geology
Laval and Hartman Townships

Ontario Geological Survey
Report 272

B.R. Berger

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Foreword

Detailed geological mapping of the Laval and Hartman townships area was undertaken by the Ontario Geological Survey, as part of the Canada–Ontario Mineral Development Agreement (COMDA), a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed in 1985 by the governments of Canada and Ontario.

The project reported here was undertaken to identify the economic potential of this portion of the Wabigoon Subprovince and to improve the geological data base.

V.G. Milne

Director
Ontario Geological Survey

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GEOLOGICAL MAP

(back pocket)

Map 2534 (coloured) Precambrain Geology, Laval and Hartman Townships. Scale 1:20 000.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

Precambrian Geology Laval and Hartman Townships

B.R. Berger

Geologist, Precambrian Geology Section, Ontario Geological Survey.

Manuscript approved for publication by A.C. Colvine, Chief Geologist, February 1989. Report published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

The study area is bounded by latitudes 49°42′26″ and 49°53′46″N and by longitudes 92°24′44″ and 92°32′38″W and includes Laval and Hartman townships in the District of Kenora (approximately 184 km^2).

The map area is underlain by a diverse assemblage of Archean supracrustal lithologies intruded by Archean felsic granitoid stocks. The supracrustal rocks are subdivided into the following major groups:

1. The Southern Volcanic Belt composed of high-iron tholeiitic basalts with subordinate calc-alkalic basalts, plagioclase-phyric basalts (leopard rock) and very minor variolitic basalts lies in the southern part of Hartman Township
2. The Minnitaki Group of turbiditic wackes, siltstones and mudstones with intercalated felsic calc-alkalic pyroclastic deposits underlies northwestern Hartman and southeastern Laval townships
3. The Abram Group of turbiditic wackes and siltstones intercalated with felsic epiclastic deposits underlies northwestern Laval Township. This group is morphologically similar to the Minnitaki Group and may be correlative with it
4. The Neepawa Group underlies central Laval Township and is subdivided into two formations. Formation A is composed of tholeiitic basalts, andesites, rhyolites and related subvolcanic intrusions. Formation B overlies formation A and is characterized by calc-alkalic basalts and andesites that contain prominent amphibole and plagioclase phenocrysts

Field relationships, textures and geochemistry indicate that spherulites in formation A of the Neepawa Group result from immiscible liquid splitting of mafic and felsic magmas. Geochemistry, mineralogy and composition of formation B rocks indicate they are calc-alkalic and resemble modern island-arc volcanic sequences.

The Hartman Lake Stock, the Sandybeach Lake Stock, the Gardnar Lake Stock and the Crossecho Lake Stock have intruded the supracrustal rocks and vary from quartz diorite to granite in composition. A distinctive suite of white and pink peraluminous granitic pegmatites and aplites occurs along the northern contact of the Sandybeach Lake Stock and extends discontinuously through central Hartman Township to the west boundary of the map area. These rocks are enriched in tin,

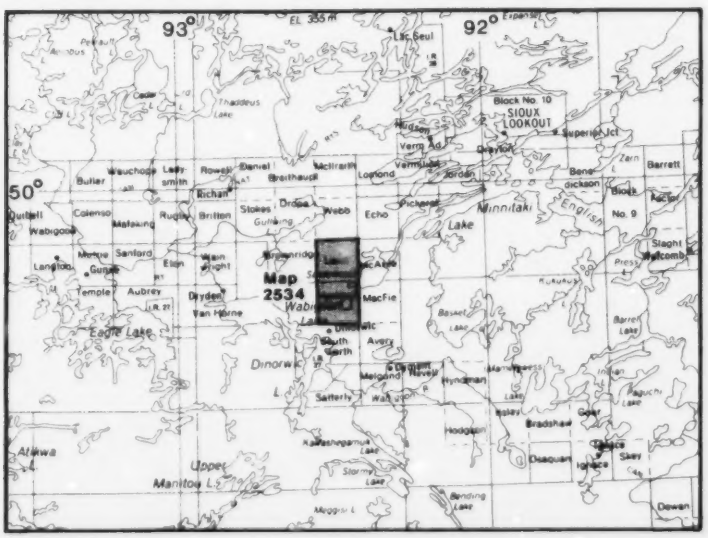


Figure 1. *Key map showing location of the Laval and Hartman townships area.*

tantalum and niobium and represent the extension of the Dryden lithium-bearing pegmatite field into the map area.

Three stages of deformation have affected the rocks in the map area.

1. The earliest deformational stage is represented by shallowly dipping strata, foliations and shear zones and is attributed to thrusting
2. Intrusion of the granitic stocks created narrow strain aureoles which steepened the earlier structures and produced steeply plunging mineral lineations in the stocks
3. Northwest compression resulted in upright folding of the supracrustal rocks, steepening and refolding of the earlier structures and creation of steeply dipping east to northeast oriented shear zones. The Wabigoon Fault, a major structural feature in the area is a third stage structure cutting all rock types including the Hartman Lake Stock. Gold mineralization is preferentially sited in third stage structures

Metamorphism spanned the stage two and stage three deformational events. Peak thermal conditions were attained during intrusion of the granitic stocks which were followed by retrograde conditions and attainment of a second thermal peak during stage three folding.

Gold is the most important economic mineral and mineralization is controlled by stage three deformational structures. Northeast-trending shear zones, east-northeast- and north-northeast-trending fractures and shears localize the known gold showings and are potential exploration targets wherever they are well developed. Where these structures encounter structurally competent bodies, fracturing may occur and these sites are particularly susceptible to gold mineralization.

Previous base metal exploration has focussed on testing airborne geophysical anomalies near the contact between the Neepawa and Minnitaki groups. Felsic metavolcanic horizons within formation A of the Neepawa Group host the known base metal showings and are a favoured exploration target.

Résumé

La zone étudiée est délimitée par les latitudes 49°42'26" et 49°53'46"N et par les longitudes 92°24'44" et 92°32'38"W et comprends les cantons de Laval et Hartman dans le District de Kenora (environ 184 km^2).

Le substratum de la zone cartographiée est constitué d'un assemblage de roches supracrustales archéennes intrudées par des massifs granitiques. Les roches supracrustales sont subdivisées dans les groupes principaux suivants:

La Ceinture Volcanique du Sud, située dans la partie sud du canton de Hartman, est composée de basaltes tholéiitiques riches en fer avec des quantités moindres de basaltes calco-alcalins, des basaltes à phénocrystaux de plagioclase (leopard rock) et des basaltes variolitiques peu abondants.

Le groupe de Minnitaki situé dans la partie nord-ouest du Canton de Hartman et la partie sud-est du canton de Laval, est composé de grauwackes turbiditiques, microgrès et de mudstones, avec des intercalations de dépôts pyroclastiques calco-alcalins.

Le groupe Abram, affleurant dans la partie nord-ouest du canton de Laval, est composé de grauwackes turbiditiques et de microgrès qui sont interstratifiés avec des dépôts épiclastiques felsiques. La constitution de ce groupe est semblable au groupe de Minnitaki et peut être corrélée avec ce dernier.

Le groupe de Neepawa qui se trouve dans la partie centrale du canton de Laval, est subdivisé en deux formations. La formation A comprend des basaltes tholéiitiques, des andésites, des rhyolites et des intrusions subvolcaniques connexes. La formation B, susjacente à la formation A, est caractérisée par des basaltes calco-alcalins et des andésites qui contiennent des phénocrystaux proéminents d'amphibole et de plagioclase.

Les relations entre les différents types de roches, les textures et la géochimie indiquent que des sphérolites contenues dans la formation A du groupe de Neepawa proviennent de la séparation de magmas felsiques et mafiques à partir d'un liquide immiscible. La géochimie, la minéralogie et la constitution des roches de la formation B indiquent qu'elles sont calco-alcalines et resemblent aux séries volcaniques des arcs insulaires récents.

Les massifs du lac Hartman, du lac Sandybeach, du lac Gardnar et du lac Crossecho ont intrudé les roches supracrustales et leurs compositions varient de la diorite quartzique au granite. Une suite distincte de pegmatites et aplites granitiques hyperalumineuses de couleur blanche à rose se trouve le long du contact nord du massif du lac Sandybeach. Cette suite s'étend de manière discontinue à travers la partie centrale du canton de Hartman jusqu'à la limite ouest du secteur cartographié. Ces roches sont enrichies en étain, tantale, niobium et représentent l'extension du champ de pegmatites à lithium de Dryden.

Les roches de la zone cartographiée ont été affectées par trois phases de déformation.

La déformation la plus ancienne est représentée par des strates à faible pendage, des foliations et des zones de cisaillement. Elle est attribuée à un charriage.

Les intrusions de massifs granitiques ont crée d'étroites auréoles de contrainte qui ont redressé le pendage des structures plus anciennes et a produit des linéations de minéraux fortement inclinées dans les massifs.

Une compression nord-ouest a produit des plis droits dans les roches supracrustales, le redressement et le replissement des structures plus anciennes avec la création de zones de cisaillement à fort pendage orientées est à nord-est. La faille de Wabigoon qui représente une structure majeure dans le secteur, est une structure de la troisième phase qui recoupe tous les différents types de roches y compris le massif du lac Hartman. La minéralisation aurifère prend place surtout dans les structures de la troisième phase de déformation.

Le métamorphisme a affecté les roches au cours de la deuxième et la troisième phase de déformation. Les conditions thermiques maximales ont eu lieu lors de

l'intrusion des massifs granitiques et ont été suivies d'un rétro-métamorphisme. Un second maximum thermique a eu lieu pendant la troisième phase de déformation.

L'or est le principal minéral d'intérêt économique. La minéralisation aurifère est controllée par les structures de la troisième phase de déformation. Les zones de cisaillement d'orientation nord-est et des fractures et zones de cisaillement orientées est-nord-est et nord-nord-est contiennent les indices aurifères connus et présentent des cibles pour l'exploration minière lorsque ces structures sont bien développées. Lorsque ces structures recoupent des roches structuralement compétentes, des fractures peuvent être produites. Ces zones de fractures sont particulièrement favorables pour la minéralisation aurifère.

L'exploration pour les métaux de base dans le passé s'est surtout portée sur la prospection des anomalies géophysiques aéroportées près du contact entre les groupes de Neepawa et de Minnitaki. Les horizons métavolcaniques felsiques au sein de la formation A du groupe de Neepawa contiennent les indices de métaux de base connus et sont les cibles favorites pour la prospection minière.

Precambrian geology, Laval and Hartman townships, by B.R. Berger, Ontario Geological Survey, Report 272, 74p. Accompanied by Map 2534, scale 1:20 000. Published 1990. ISBN 0-7729-6516-1.

Introduction

Laval and Hartman townships are bounded by latitudes 49°42′26″ and 49°53′46″N and longitudes 92°24′44″ and 92°32′38″W. Both townships were mapped (approximately 184 km^2) at 1:15 840 scale in an effort to improve the geological data base for this area. Highway 72 traverses the central part of Hartman Township and the southeastern part of Laval Township and provides easy access from Dryden (43 km west) and Sioux Lookout (55 km northeast). Seasonal gravel and bush roads provide access to most of the map area, however, fixed-wing aircraft was used to access the Rafter Lake area in western Laval Township. Portages between Troutfly and Beartrack lakes and between Beartrack and Gardnar lakes permitted access to these areas and only the southwestern part of Laval Township was inaccessible.

History of Exploration

There are no known economic mineral deposits within the map area; however, there are three gold showings and the Goldlund gold mine, a past producer, occurs approximately 1 km northeast of the map area. Hurst (1933) indicated the entire Sioux Lookout area was explored for gold in the early 1900s and Satterly (1943) reported that only cursory exploration was carried out in the map area up to the outbreak of World War II.

Discovery of gold mineralization in Echo Township sparked intense exploration activity between 1946–1952 and resulted in the discovery of the Goldlund deposit (Page and Christie 1980a, 1980b). At this time a number of companies carried out exploration in Laval Township searching for gold mineralization and three significant discoveries were made; namely, the Calder Bousquet showing at the south end of Troutfly Lake and the Graham Bousquet No. 1 and No. 2 showings on Beartrack Lake.

Exploration for base metals began in the 1970s and has been sporadic since. A number of companies have flown airborne electromagnetic and magnetic surveys and have tested selected geophysical anomalies by diamond drilling. To date no significant base metal mineralization has been discovered.

Laval Township was actively being explored during the 1987 field season. A number of mining claims were in good standing at this time and Mistango Consolidated Resources Limited had commenced diamond drilling on the gold showing at the south end of Troutfly Lake. The gold showings on Beartrack Lake were staked but have not been explored since their discovery in 1950.

Previous Geological Work

The earliest references to the geology of the map area are in the reports of Bell (1873), Coleman (1896), Parks (1898), Bow (1899, 1900) and McInnes (1905). Hurst (1933) mapped the Sioux Lookout area in 1932. Satterly (1943) mapped Laval and Hartman townships at 1:63 360 scale as part of the much larger Dryden–Wabigoon area. Armstrong (1951) mapped Echo Township at 1 inch to 1000 feet following the discovery of gold in the area and Chisholm (1951) published a preliminary account of mining activity covering the area northeast of Laval Township. Sutcliffe (1977) mapped parts of Hartman Township and his results have been incorporated into Map 2534 that accompanies this report (back pocket). Page (1984) reported on the area north of Laval Township and summarized many of the critical features at the Goldlund deposit which the author has referred to throughout this report. Ontario Geological Survey data series Maps P.2332 and P.2334 (Speed and Maxwell 1980a, 1980b) and Geological Data Inventory Folio 341 (Ontario Geological Survey 1986) cover the map area. Berger (1989) and Berger et al. (1989a, 1989b) reported on the area immediately east of Laval and Hartman townships. Chorlton (1986, 1988) deals with various economic and structural aspects in the area.

The map area was surveyed aeromagnetically in 1961 at 1:63 360 (Ontario Department of Mines–Geological Survey of Canada 1961a, 1961b). Geophysical maps for part of the Dryden area cover the map area (Ontario Geological Survey 1987a-f).

Scientific studies have been written on various aspects of the geology of the area. Pettijohn (1939), Walker and Pettijohn (1971), Turner and Walker (1973), Trowell et al. (1980, 1983) and Blackburn et al. (1985) have addressed aspects of the supracrustal stratigraphy in the Sioux Lookout area and their work is referred to in this report.

Present Survey

Laval and Hartman townships were mapped at 1:15 840 scale during the 1987 field season. The mapping crew comprised one geologist, one senior assistant and three junior assistants augmented by a fourth assistant during the month of August. Standard pace and compass traverses using 1:15 840 scale black and white, vertical aerial photographs for control were carried out in conjunction with shoreline and roadside traverses to map the area. Traverses were spaced to provide coverage of the entire area, however, in areas of dense outcrop several closely space traverses were carried out.

Data taken in the field were plotted on acetate overlays to aerial photographs which were then transferred to base maps prepared by the Cartography Section, Ontario Division of Lands, from maps of the Forest Resources Inventory, Ontario Ministry of Natural Resources.

Physiography

The map area lies within the English River drainage basin which is part of the Arctic watershed. Drainage patterns are poorly developed and locally controlled by bedrock structures and glacial features. Southern Laval Township and northern Hartman Township are underlain by extensive subaerial glacial outwash deposits associated with the Hartman Moraine (Cowan 1987). Sand and pebble gravel deposits comprise most of the sediments in this area (Cowan 1987). Southwestern Laval Township is underlain by wetland and peat deposits and this area along with much of the outwash deposits form part of the Lola Lake Provincial Nature Preserve (Government of Ontario 1985).

The map area is characterized by gentle relief, seldom exceeding 10 m. Outcrop density varies from 1 to 5 percent in northern Hartman Township to over 60 percent in central Laval Township with an average density around 20 to 30 percent. As is typical of many northwestern Ontario "greenstone" terranes, many outcrops are not visible on 1:15 840 aerial photographs and require traversing and vegetation stripping to expose hidden rocks.

Acknowledgments

Clive Stephenson capably served as senior assistant on this project and carried out independent mapping over approximately 50 percent of the area. D.S. Jeffrey, V. Arthur, A. Tims and A. Tuomi, an exchange student from Finland, provided competent assistance. Mr. Jeffrey carried out independent mapping over most of the Crossecho Lake Stock and immediate contact areas in the later half of the field season. This project was carried out in conjunction with studies by L.B. Chorlton, of the Ontario Geological Survey. Several of her observations and conclusions are included in this report and the author gratefully acknowledges her contribution.

Logistical support by the Ministry of Natural Resources in Dryden and Sioux Lookout is gratefully acknowledged as is the support from the Resident Geologists' offices in Sioux Lookout and Kenora.

General Geology

Laval and Hartman townships are underlain by Archean rocks of the Superior Province of the Canadian Shield. Supracrustal lithologies (Ayres et al. 1985) comprise approximately 80 percent of the map area and are composed of mafic, intermediate and felsic metavolcanics, related subvolcanic intrusions composed of gabbroic sheets and dikes, feldspar- and quartz-feldspar-phyric dikes, and clastic and chemical metasediments. Felsic plutonic rocks composed of granodiorite, quartz monzonite, granite, monzonite and tonalite have intruded the supracrustal rocks in four spatially separated stocks. A distinctive suite of granitic pegmatite and aplite intrusions also occurs within the map area.

A number of previous workers (Pettijohn 1939; Satterly 1943; Turner and Walker 1973; Trowell et al. 1980; Trowell, in preparation) have undertaken either detailed or regional stratigraphic studies in the Sioux Lookout–Dryden areas and have proposed group names for various packages of lithologies. Berger et al. (1989a, 1989b) in the area adjacent to Laval and Hartman townships correlated lithologies with groups proposed by Turner and Walker (1973) and modified by Page and Clifford (1977) and Trowell (in preparation) in the Sioux Lookout area. Lithologies in the map area are correlated with the Southern Volcanic Belt, the Abram Group, the Minnitaki Group and the Neepawa Group. The Neepawa Group has been further subdivided by the author into two formations which as yet have not been regionally correlated with other Neepawa Group formations.

The entire map area has undergone three stages of deformation as determined by Chorlton (1987). The first stage of deformation resulted in gently dipping structures which are best observed in the Troutfly–Diamond lakes area. Here gently to moderately dipping metagabbro-"altered gabbro" sheets and mafic to felsic metavolcanics exert a local topographic control and preserve subhorizontal to moderately dipping foliations, fold axes, lineations and shear zones. It is possible that thrusting or low angle listric faulting may have been responsible for the deformation (Chorlton 1987).

The second stage deformation is characterized by steeply plunging lineations and foliations developed within contact strain and thermal aureoles developed around the granitoid stocks. Foliations are concentric around the intrusions and first stage deformational structures are warped and generally steepened. The second stage deformation was caused by emplacement of the granitoid stocks (Chorlton 1987).

The third stage deformation is characterized by upright folds in the supracrustal rocks, steepening and refolding of the earlier structures and creation of steeply dipping easterly to northeasterly trending shear zones. The third stage deformation was caused by northwest-southeast transpression and northeast shear zones generally display sinistral movement with a locally strong dip-slip component. The Wabigoon Fault is a stage three deformational feature and based on abrupt changes in lithology, styles of deformation and metamorphic grade across the structure it has been cited as the Wabigoon–English River subprovincial boundary in the Dryden area (Breaks et al. 1978; Blackburn et al. 1985). In the map area lithologies appear to be continuous across the fault and there is a common deformational history throughout the area. Furthermore, complex metamorphic patterns and the fading of the fault's effects precludes using the Wabigoon Fault as a subprovincial boundary. All rocks are within the Wabigoon Subprovince in Laval and Hartman townships.

Gold mineralization is localized in third stage deformational structures which are prospective exploration targets especially where they have fractured and flexed structurally competent bodies. In Laval Township three gold showings are hosted in or near fractured and sheared metagabbro-metadiorite intrusions.

Note that in the following descriptions of supracrustal units all rocks have been metamorphosed. No rock has retained its original mineralogy and/or texture. The prefix "meta" has been omitted for brevity when referring to individual rock types and will only be used in the general sense, i.e., metasediments and metavolcanics.

Table 1 outlines lithologies in the map area.

EARLY TO LATE ARCHEAN

MAFIC METAVOLCANICS

Mafic metavolcanics underlie southeastern, southwestern and the central part of Hartman Township and form a separate continuous band extending from northeastern to southwestern Laval Township. Amphibolite to amphibolitic gneiss occurs within metasediments in north-central Hartman Township.

The mafic metavolcanics underlying southeastern and southwestern Hartman Township are composed predominantly of flows with subordinate mafic tuffs and hyaloclastite. Massive flows are the most abundant rock type and are commonly dark green to black, fine- to medium-grained, non-vesiculated rocks. Plagioclase-phyric flows ("leopard rock") containing 5 to 25 percent white anhedral to subhedral plagioclase phenocrysts are common in southeastern Hartman Township but absent in the southwest. These rocks have an aphanitic to fine-grained groundmass and highly inhomogeneous phenocryst density which is interpreted as a flow feature.

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE LAVAL AND HARTMAN TOWNSHIPS AREA.

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT

Swamp, lake and stream deposits

Unconformity

PRECAMBRIAN

ARCHEAN

LATE ARCHEAN

MAFIC INTRUSIONS

Lamprophyre dikes.

EARLY TO LATE ARCHEAN

FELSIC INTRUSIONS

Granodiorite, granite, tonalite, quartz monzonite, monzonite, quartz diorite, monzogabbro, pegmatite, aplite.

MAFIC INTRUSIONS

Gabbro, diorite, leucogabbro, plagioclase-phyric gabbro, quartz diorite, gabbroic dikes, altered gabbro.

CLASTIC AND CHEMICAL METASEDIMENTS

Wacke, siltstone, mafic wacke, pebbly wacke, argillaceous, phyllitic and biotite-muscovite-quartz schist, hornblende-garnet-biotite amphibolite, sulphide-magnetite and magnetite ironstone, chert, and metatexite.

FELSIC TO INTERMEDIATE METAVOLCANICS

Massive, spherulitic and autobrecciated flows, tuff and crystal tuff, lapilli tuff, breccia, feldspar, quartz and quartz-feldspar-phyric dikes, quartz-muscovite schist.

HORNBLENDE-PHYRIC MAFIC TO INTERMEDIATE METAVOLCANICS

Massive and pillowed flows, tuff and crystal tuff, lapilli tuff and lapillistone, tuff breccia and breccia, pillow breccia, chlorite schist, basaltic dikes and sills.

MAFIC METAVOLCANICS

Massive, pillowed and variolitic flows, pillow breccia, tuff, lapilli tuff and lapillistone, breccia and tuff breccia, basaltic dikes and sills, amphibolite, talc-chlorite and talc-chlorite-carbonate schist, plagioclase-phyric flows.

Pillowed flows are common in both the southeast and southwest corners of Hartman Township. These rocks are dark green, aphanitic and pillows average 40 to 50 cm by 10 to 25 cm with 0.5 to 1 cm thick rims. Pillows are generally closely packed, well formed to partially brecciated and contain less than 5 percent vesicles (1.5 mm diameter). Small oval varioles (5 mm average) in pillows were observed at one location along the Hartman–Zealand Township line.

Mafic tuff is subordinate to flows and occurs as narrow discontinuous units in the southern part of the map area. Individual beds are from 1 to 8 cm thick in units up to 1 m thick and generally green to grey except where they contain finely disseminated pyrite and pyrrhotite in which case they are very rusty. Graded bedding was observed in one place in the southeast part of Hartman Township and here tops were to the east.

Talc-chlorite and talc-chlorite-carbonate schist is commonly developed where mafic metavolcanics are sheared. In the southeast corner of Hartman Township, schists are well developed in an extensive northeast-trending shear zone. Here green to dark green fine-grained to fissile talc-chlorite schist is predominant and contains sinistrally rotated epidote clots and kink bands. Rocks with more than 10 percent carbonate were described as talc-chlorite-carbonate schists. In these rocks ankerite and calcite occur in stringers with or without quartz parallel to and crosscutting foliation planes and also occur pervasively throughout the schist. Pyrite and chalcopyrite are rarely present and seldom comprise more than 5 percent of the rock in this area.

Along Highway 72 in southern Hartman Township, talc-chlorite schists contain abundant sulphides. Pyrite, pyrrhotite and trace chalcopyrite from trace up to 90 percent of rock occur along foliation planes and in stringers throughout the rock. A well-developed gossan and deeply weathered regolith are developed over the most massive sulphides. This zone has been previously explored by Canadian Nickel Company Limited (*see* Economic Geology).

The mafic metavolcanics in southeastern Hartman Township are contiguous with mafic metavolcanics correlated with the Southern Volcanic Belt to the east (Berger et al. 1989a, 1989b). These rocks extend south of the map area around the Hartman Lake Stock and re-enter Hartman Township in the south-

west and are also correlated with the Southern Volcanic Belt. Satterly (1943) included these mafic metavolcanics within the Wabigoon Volcanics. This implies the equivalence of the Wabigoon Volcanics and the Southern Volcanic Belt; however, further detailed mapping south of map area is required to firmly establish this correlation. In particular, regional deformation zones along which sense and amount of movement are unknown are present in the Dinorwic Lake area and correlation of units across these zones is tenuous (Satterly 1943; Blackburn 1982).

The general absence of vesicles in the flows, absence of pyroclastic deposits and clastic metasediments indicate these mafic rocks were rapidly deposited in relatively deep water (cf. Jones 1969; Easton and Johns 1986). Southern Volcanic Belt members east of the map area generally exhibit these same "deep water" features; however, shoaling sequences recognized by the presence of high vesicularity in flows, irregular pillow shapes and thick flows (greater than 20 m) do occur in the Avery Lake area (Berger et al. 1989a, 1989b; Berger 1989).

Mafic metavolcanics underlie the central part of Hartman Township west of Hartman Lake. These rocks are composed predominantly of massive and pillowed flows, some of which contain varioles. Amphibolite is common as this area is generally metamorphosed to upper greenschist-lower amphibolite facies. Subordinate rock types in this area are lapilli tuff, tuff breccia and pillow breccia. Wacke, siltstone and mafic wacke units are tectonically intercalated with these mafic metavolcanics (Chorlton 1988).

Massive flows in this area are dark green to black, fine- to medium-grained rocks with few if any vesicles or amygdules. In many places massive flows contain white oval to stretched varioles varying from 5 mm to 2 cm in size and from 5 to 25 percent of the rock. Pillowed flows are very common and pillows are usually well formed, 30 to 50 cm long by 10 to 30 cm wide, and closely packed with 0.5 to 1 cm thick rims. White varioles, 5 mm to 1 cm, occur in several areas within pillows; however, no distinctive marker unit was recognized and variolites were not traced for more than 100 m. Most varioles are white featureless ovoids; however, at one location concentric zoning was observed where a dark epidotic core was surrounded by a white feldspathic rim. A more thorough discussion of variolites and spherulites is presented below as the variolites in central Hartman Township are poorly exposed and highly metamorphosed and morphologically simple compared to variolites exposed in Laval Township.

Mafic fragmental rocks occur in a couple of locations in central Hartman Township. Pillow breccia is poorly exposed at one location and consists of highly metamorphosed dark green centimetre-sized fragments in a black amphibolitic matrix. Pillowed flows occur nearby but contacts were not observed. Lapilli tuff and tuff breccia were identified in a deformed and highly metamorphosed outcrop near the western boundary of Hartman Township. White feldspathic fragments from 0.4 to 15 cm in size occur in a dark green amphibolitic matrix and crude layering separates relatively coarse fragments from relatively fine fragments. No consistent sense of grading was observed and the unit could not be traced for more than 50 m.

Dark green to black rocks which were highly recrystallized to dense featureless to foliated mats of hornblende, epidote and rarely garnet were mapped as amphibolites. These rocks are widespread in central Hartman Township and indicate that relatively high metamorphism and deformation has affected this area.

The general absence of vesicles indicates that these rocks were deposited in relatively deep water (Jones 1969). Stratigraphic facings derived from pillow shapes indicate these rocks are folded about northeast-trending axes and stratigraphy is difficult to interpret because of the folding. Intrusion of the Hartman Lake granitoid stock and the influence of the Wabigoon Fault further complicate interpretation. Based on aeromagnetic data (Ontario Geological Survey 1987c) and the distribution of lithologies, the mafic metavolcanics are inferred to be contiguous with members of the Southern Volcanic Belt in southwestern Hartman Township. Satterly (1943) assigned these rocks in central Hartman Township to the Thunder River Volcanics and indicated these rocks were separated from the Wabigoon Volcanics (Southern Volcanic Belt?) by clastic metasediments (Zealand Sediments). Satterly (1943) observed that the Thunder River Volcanics were folded and that they wedged out west of Dryden. He concluded that the Thunder River Volcanics were derived from a source to the east of the map area. This interpretation is consistent with the Thunder River Volcanics being equivalent to the Southern Volcanic Belt metavolcanics. Further, the deep water depositional environment and presence of morphologically similar variolites in central and southwestern Hartman Township suggests the mafic metavolcanics are equivalent in both areas.

Mafic metavolcanics underlie central Laval Township and occur in two modes. Mafic metavolcanics that contain hornblende and relict pyroxene phenocrysts occur between Beartrack–Gardnar and Troutfly lakes and are associated with intermediate metavolcanics. These type metavolcanics are described in greater detail in the next section (Hornblende-phyric Intermediate and Mafic Metavolcanics). The more abundant type of mafic metavolcanics in Laval Township are hornblende-pyroxene aphyric and are associated with intermediate and felsic metavolcanics. This suite of rocks occurs south of Troutfly Lake to Diamond Lake and west to Rafter Lake. It also occurs west of Beartrack Lake to the north of Rafter Lake and, therefore, encircles all members of the hornblende-pyroxene-phyric suite of rocks.

The more abundant mafic metavolcanics are composed of massive, variolitic and pillowed flows,

pillow breccias, heterolithic pyroclastic rocks, and are associated with basaltic dikes and sills and amphibolite.

Massive flows are dark green to black, fine to medium grained and commonly have a subophitic texture. Gabbroic dikes and sills intrude the flows and occur as shallowly to steeply dipping sheets. Separation of the coarser grained flows from the intrusions is difficult as contacts are poorly exposed and numerous mafic xenoliths are common in the intrusions. For the most part, flows are nonvesicular; however, in a few places calcite-filled gas cavities up to 1 cm diameter were observed but they do not comprise more than 5 percent of the rock.

Green to dark green pillowed flows are common throughout this sequence and pillows are generally 50 to 100 cm by 20 to 50 cm in size. Pillows are generally closely packed with 0.5 to 1 cm thick rims and contain less than 5 percent vesicles. In two places west of Diamond Lake very large pillows up to 2 m long were observed. These pillows are green to grey with thick rims (up to 3 cm) and 5 to 10 percent calcite-filled amygdules which are 3 to 7 mm in diameter. These pillowed flows based on visual examination only, are andesitic to dacitic in composition; whereas, the more abundant pillowed flows are basaltic.

Pillow breccias and flow breccias occur in a few places in this sequence and where observed are commonly narrow units 1 to 10 m thick and not extensive. Fragments vary from less than 1 to 15 cm and are generally rounded although angular fragments are present. At one place on the west shore of Beartrack Lake, white chert fragments and layers occur within and at the top of a pillow breccia. The pillow breccia is in close proximity to the contact with hornblende-pyroxene-phyric rocks and the presence of chert is interpreted as a product of volcanic exhalation during a hiatus between volcanic episodes.

At another location approximately 200 m southwest of Diamond Lake a distinctive flow breccia is exposed. Subrounded to amoeboid chalky white to grey fragments up to 15 cm occur in a highly recrystallized hornblende-plagioclase-phyric matrix. Disseminated pyrite is erratically distributed in the matrix and hornblende-rich pods occur in a few of the felsic fragments. Several of the larger fragments have 2 mm to 1 cm chilled white rims and grey core zones commonly with small hornblende crystals. Some of the smaller fragments have diffuse contacts with mafic crystals penetrating into the fragments and other felsic fragments are surrounded by a dark green dense mat of hornblende.

Approximately 1600 m to the east a similar flow top breccia is exposed along an old bush road. Here felsic fragments containing anhedral plagioclase up to 1 cm in size occur in a mafic matrix. This flow is in contact with a highly metamorphosed flow banded intermediate unit of similar composition as the felsic fragments (Photo 1). There is an abrupt irregular contact between the flow banded unit and the flow top breccia marked by mafic veining and embayments of the intermediate flow in mafic material. A few felsic fragments contain recrystallized hornblende-rich cores and chilled margins occur on several other fragments. Alternatively, some smaller fragments are very wisp shaped with diffuse boundaries and appear to have reacted with the mafic matrix.

The apparent compositional contrast between fragment and matrix at both locations is enhanced by regional metamorphism and hornblende-calcite alteration which has selectively replaced matrix in preference to fragments. It is most likely these breccias are flow top and pillow breccias, although the mafic veining and apparent reaction with the matrix of some of the smaller fragments suggest mixing of a felsic and mafic magma may have occurred (Yoder 1973).

Mafic pyroclastic deposits are common in Laval Township and are composed of tuff, lapilli tuff and tuff breccia. Tuffs are generally fine-grained green rocks with a granular texture as opposed to interlocking crystals typical of massive flows. Tuffs are commonly highly foliated and occur throughout the sequence although they tend to be more abundant near variolites.

Heterolithic lapilli tuff occurs at several places in this mafic sequence and is characterized by subrounded white felsic clasts of an average size of 1 to 3 cm in a mafic, highly metamorphosed aphyric matrix. These rocks are generally clast supported, poorly sorted, unstratified and ungraded. Individual units could not be traced for more than 100 m and they occur throughout the sequence, although lapilli tuff appears to be more abundant west of Gardnar Lake near and interbedded with units of hornblende-pyroxene-phyric intermediate pyroclastic rocks.

Mafic tuff breccia and breccia are also common in Laval Township. These units are heterolithic to monolithic with clasts ranging from 6 cm to 1 m in size in a tuff or lapilli tuff matrix. Fragments are basaltic to rhyolitic and in one unit blocks of flow laminated dacite suggesting an epiclastic origin were observed. For the most part, these deposits are unsorted, ungraded and poorly stratified and have a high matrix to clast ratio (i.e., 60:40 or more). Fragments are rounded to angular and in many places both matrix and clast are very vesicular.

At one location, east of Rafter Lake, a monolithic breccia composed of rounded to angular nonvesicular basaltic fragments, 3 to 35 cm in size is exposed in a single outcrop of approximately 50 m^2 size. The breccia is clast supported, ungraded, unsorted, unstratified and appears to have either formed *in situ* or to have rapidly accumulated without preservation of flow structures. It is possible that this breccia is a block and ash deposit preserved in a paleotopographic low (cf. Easton and Johns 1986).

Tuff breccias and breccias occur throughout the mafic metavolcanic sequence but tend to be more abundant east of Rafter Lake and near the contact

Photo 1. *Flow-banded tholeiitic andesite from formation A, Neepawa Group. Located on a bush road east of Diamond Lake, Laval Township (cf. geochemical sample 87BRB-0229, Table 4).*

with the hornblende-pyroxene-phyric metavolcanic sequence. The mafic pyroclastic deposits are generally interlayered with flows and less commonly with sulphide facies ironstone south of Rafter Lake. They do not form thick or extensive units.

In areas of high strain and metamorphism, mafic metavolcanics are recrystallized to amphibolites. Amphibolites are black to dark green rocks and are generally foliated and devoid of recognizable primary features. Amphibolites are common north of Rafter Lake, southwest of Diamond Lake, near the contacts of gabbroic sheets between Diamond Lake and the eastern boundary of Laval Township. Where deformation is severe as along the metavolcanic-metasedimentary contact and east of Troutfly Lake, talc-chlorite and talc-chlorite-carbonate schists are developed along with amphibolite.

Basaltic dikes and sills occur in several places in Laval Township and are recognized on the basis of clearly observable chilled margins. Observed dikes and sills are narrow, i.e., only 8 cm to 2 m thick, and could not be traced beyond the limits of single outcrops. These intrusions are grey to green, very fine grained to aphanitic and generally very brittle. Several dikes were observed on Beartrack Lake cutting mafic and intermediate pyroclastic rocks and are spatially associated with a metagabbro-metadiorite stock.

Variolites are common in this mafic metavolcanic sequence of rocks and they are important marker units as gold and base metal mineralization is spatially associated with their occurrence. Terminology is very important to the subsequent descriptions as variolites in Laval Township display complex morphologies with a complete gradation between end numbers. A variole is a pea-size spherule, usually composed of radiating crystals of plagioclase or pyroxene and the term is generally applied only to such spherical bodies in basic igneous rocks (e.g., variolites) (Bates and Jackson 1987). Additionally, spherulite is a rounded or spherical mass of acicular crystals radiating from a central point and may range in size from microscopic to several centimetres in diameter (Bates and Jackson 1987). The immediate problem with applying either of these terms to the rocks in the map area is that internal structures are generally absent in the spheres. Most commonly the spheres are circular, elliptical or irregular where they are coalesced. They have either a uniform white to chalky colour or a white to chalky rim with small 1 to 3 mm dark grey to black cores. Only in Mistango Consolidated Resources Limited diamond-drill core (hole 87-1) were radial internal structures observed in a couple of spheres. For the most part, lack of internal structures is interpreted as having resulted from deformation and metamorphic recrystallization of the spheres. It is assumed that pri-

mary, internal radial structures were originally present and use of the terms variolite and spherulite are appropriate.

Variolites are the most common rock type in this sequence; however, in many places spherulites up to 5 cm in a mafic magnetite-rich groundmass or millimetre-sized felsic spherulites in a felsic groundmass are present. At one location at the south end of Troutfly Lake, large spherulites up to 5 cm in size (Photo 2) in a mafic groundmass gradationally pass into varioles, many of which are coalesced in a mafic groundmass (Photo 3). This rock grades over a couple of metres into a spherulitic rock with 5 to 7 mm white spherules in a dense, black, very siliceous groundmass. This latter transition was also observed in Mistango Consolidated Resources Limited diamond-drill hole 87-1 where variolitic basalt grades over 1.5 m into spherulitic rock and over another 1.5 m grades into a massive, black siliceous flow. The entire transition occurs over 20 m across strike and variole-spherulite density steadily increases from 50 to 60 percent large spherulites to 100 percent totally coalesced felsic spherulites.

The transition from a mafic groundmass to a felsic groundmass with approximately constant-sized spherulites of 3 to 7 mm was observed at several locations southwest of Troutfly Lake. At these locations the felsic groundmass is light brown to creamy white and these rocks were mapped as a separate unit (unit 2b on Map 2534, back pocket; Photo 4) from the variolite (unit 1b on Map 2534, back pocket). At each location gabbro or "altered gabbro" similar to that hosting the Mistango gold showing (*see* Economic Geology) occurs nearby.

At several locations pairs of coalesced spherulites displayed oval outlines, and low angles at the junction point (cusp) were observed and only a few of the larger spherulites showed high angle cusps (i.e., "figure-eight" symmetry). In many places, layers of entirely coalesced felsic spherulites occur in gradational contact with variolitic-spherulitic units and in other places large, irregular coalesced masses of felsic material in a matrix of smaller spherulites gives the rock a fragmental appearance.

At a few locations, felsic spherulites of similar composition to that in flows were observed in felsic tuff. Here the spherulites are generally deformed and occur as matrix- to clast-supported fragments up to 1 cm long. Several spherulites have dark silicic cores and chalky white rims and few have vuggy cores. In this setting these spherulites may be related to pisolites.

Gelinas et al. (1976) studied Archean variolites in the Abitibi greenstone belt and they recognized two major modes of occurrence. The first type of variolite comprised mafic lavas, mainly pillowed, with small

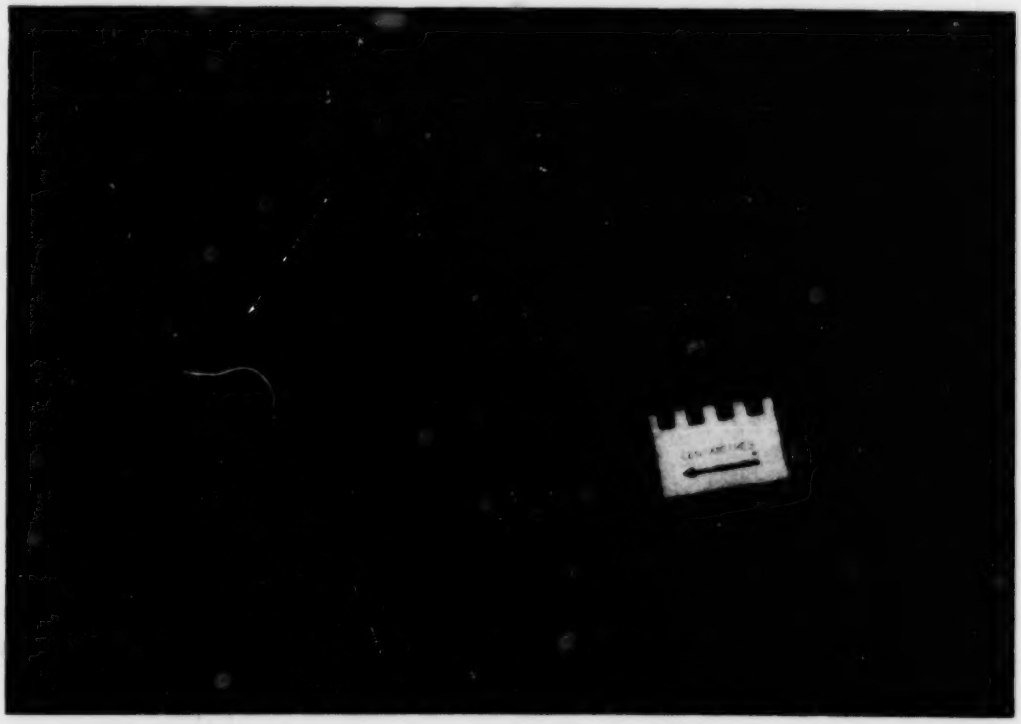


Photo 2. ***Large felsic spherulites in a mafic groundmass at the Mistango Main showing. Textures are interpreted to result from immiscible liquid separation. Formation A, Neepawa Group, southwest shore Troutfly Lake, Laval Township.***

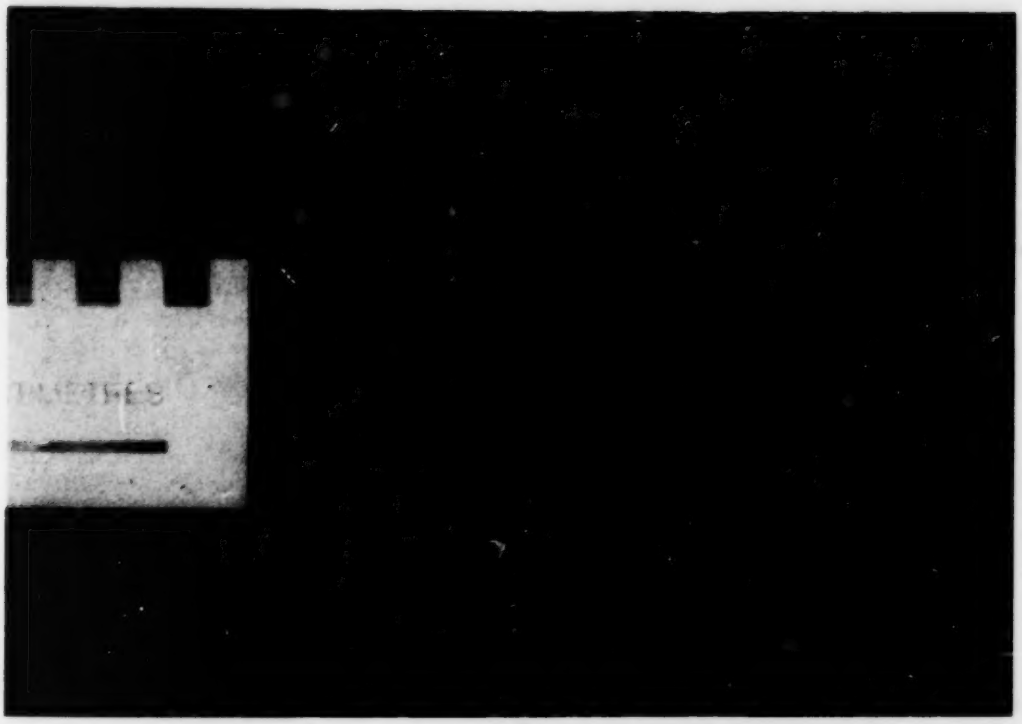


Photo 3. *Coalesced varioles in basaltic groundmass at the Mistango Main showing, southwest shore of Troutfly Lake, Laval Township. Evidence for immiscible liquids in formation A, Neepawa Group.*

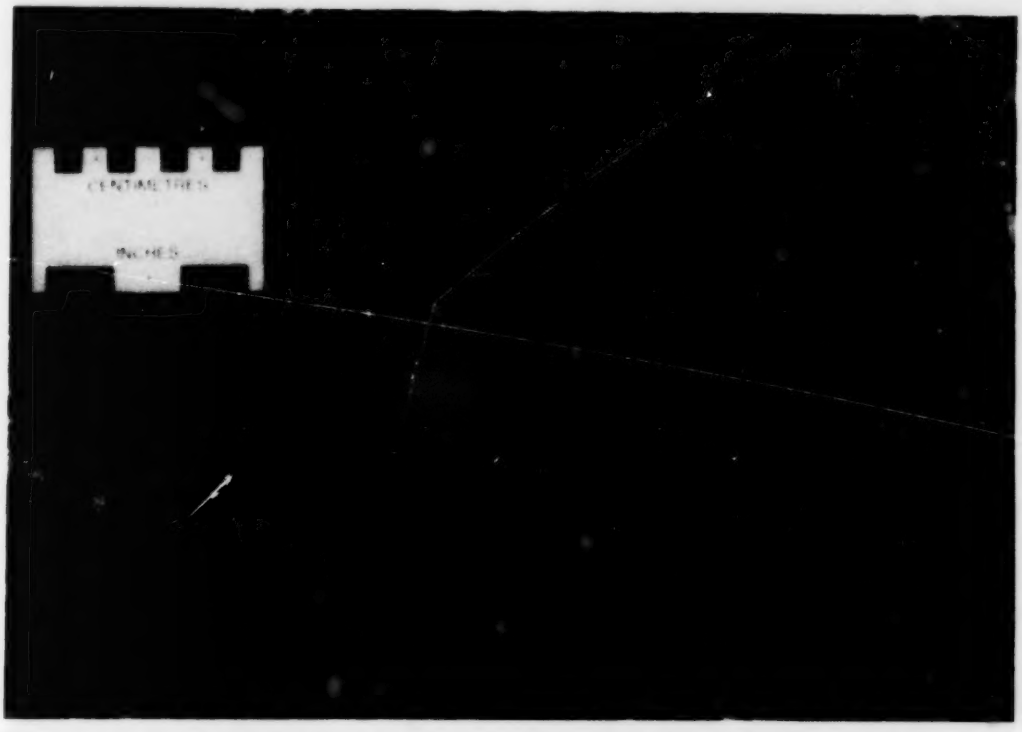


Photo 4. *Felsic spherulites in a felsic groundmass in formation A, Neepawa Group. Located in vicinity of lead-zinc-silver showing (Hollinger Mines Limited), southwest Laval Township.*

0.05 to 2 mm spherical bodies displaying a single radiating intergrowth of acicular clinopyroxenes and plagioclases (Gelinas et al. 1976). This type of variolite was referred to as Kinojevis type and rapid, immature crystallization was thought to be the mode of origin (Gelinas et al. 1976). Note that the Kinojevis type variolite closely approximates the Bates and Jackson (1987) definition for variole-variolite.

The second type of variolite referred to as the Blake River type has diverse morphologies, and varioles vary in size from 5 mm to 5 cm. Varioles are white with blue-grey cores, set in a dark green, mafic matrix and occur in massive and pillowed flows and in hyaloclastites. Coalesced varioles were common and small felsic lenses and discontinuous layers were produced in some cases. Angular fragments and felsic lenses occur with the hyaloclastites and give the rock a fragmental appearance. The Blake River type variolite closely approximates the field descriptions for the variolites in Laval Township; however, the variation in "variole" size from 3 mm to 5 cm indicates spherulite is the proper term for these spheres (Bates and Jackson 1987). Gelinas et al. (1976) concluded that Blake River variolites were formed by rapid cooling of a two-liquid magma at the point of extrusion. This magma arose by immiscible splitting within the magma chamber and varioles developed prior to extrusion (Gelinas et al. 1976).

Gelinas et al. (1976) used petrographic criteria based on Bowen's (1928) theoretical work to conclude that 1) variole and matrix were two glasses of different composition occurring in the same rock; 2) identical crystals occurred in both variole and matrix and 3) all stages of spherulite coalescence, including formation of distinct layers occurred in the Blake River type variolite. Chemically, Gelinas et al. (1976) noted that the variolite data defined an iron-enrichment trend that plotted within a miscibility gap defined for lunar rocks.

Gelinas et al. (1976) proposed that liquid immiscibility accounted for these observations. This theory has been questioned by Hughes (1977), Philpotts (1977), Cawthorn (1977) and most recently by Fowler et al. (1987). These workers prefer either post-formational alteration processes selectively enhancing the varioles or that spherulitic crystallization or both produced the varioles. Hughes' (1977) and Philpotts' (1977) arguments are effectively countered by Gelinas et al. (1977) and the more recent work by Fowler et al. (1987) appears to deal only with Kinojevis type variolites which Gelinas et al. (1976) did not study because they concluded that the varioles grew by spherulitic crystallization.

The metamorphism and deformation of the variolites-spherulites in the map area has destroyed much of the petrographic details and these rocks were not studied in detail chemically. Therefore, more study is required to adequately determine the varioles-spherulites mode of origin in these rocks. However, based upon the large spherulite size (up to 5 cm), the transition from mafic groundmass to felsic groundmass, low angle cuspate to amoeboid coalesced variole interfaces and complete coalescence into felsic layers, the rocks in the map area are concluded to be Blake River type variolites and by inference are assumed to have formed by immiscible liquid splitting prior to extrusion (Gelinas et al. 1976).

Reid (1978) carried out a petrographic and geochemical study of variolites along Highway 72 northeast of the map area. These rocks appear to be the same mafic suite as the variolites within the map area and that also occur at the Goldlund Mine in Echo Township (Chorlton 1987). Reid (1978) indicated that varioles seldom exceed 1 cm in diameter, occur in massive and pillowed flows in an iron-rich mafic groundmass and can be coalesced into felsic lenses. These rocks are not as highly metamorphosed as the variolites-spherulites in the map area and commonly retain internal radial structures. Reid (1978) concluded these varioles formed by spherulitic crystallization because varioles maintained their contacts or joined by a figure-eight interface; the primary radiating texture of the varioles indicates they grew as plagioclase spherulites and the presence of relict quench clinopyroxene in the matrix indicates the matrix crystallized and did not quench to a glass.

The mafic suite of rocks containing the variolites-spherulites extends west and northeast of the map area. Examination of Hollinger Mines Limited diamond-drill core stored at the Kenora Drill Core Library indicates units of the mafic suite occur south of Rafter Lake and provide the most reliable data base for this area. To the northeast in McAree Township, Berger et al. (1987a, 1987b, 1987c, 1989a, 1989b) mapped similar mafic units and correlated the rocks with the Neepawa Group (Trowell et al. 1983) also known as the Central Volcanic Belt (Turner and Walker 1973). In McAree Township, Neepawa Group mafic metavolcanics are interlayered and overlain by felsic metavolcanic flows and thick proximal pyroclastic deposits (Berger 1989). This sequence extends into Laval Township; however, felsic pyroclastic deposits are greatly diminished in volume and felsic flows are spherulitic and flow laminated. The mafic metavolcanic suite has been assigned formational status in the map area and has been informally designed formation A by the author. Page and Clifford (1977), Trowell et al. (1983) and Trowell (in preparation) have worked on various aspects of Neepawa Group stratigraphy and it appears formation A may correspond with the middle sequence of the Neepawa Group (Trowell, in preparation). Further detailed mapping northeast of the map area is required to confirm this correlation.

Petrographic Summary of the Mafic Metavolcanics

The mafic metavolcanics are characterized by a low metamorphic grade mineral assemblage, namely:

1. Plagioclase + chlorite + carbonate + quartz + epidote ± amphibole

and a medium metamorphic grade mineral assemblage, namely:

2. Plagioclase (An_{31-36}) + quartz + amphibole + epidote ± titanite ± biotite ± garnet ± carbonate ± chlorite.

Plagioclase in mineral assemblage 1 is largely converted to quartz, albite and epidote but a few optical determinations indicate a plagioclase composition of approximately An_{12}. Mineral assemblage 1 rocks are generally fine grained, contain much chlorite, pinhead sized epidote and fine- to medium-grained carbonate. These rocks tend to be most abundant in southeast Hartman Township and in localized areas around Beartrack Lake and east of Gardnar Lake.

Mineral assemblage 2 represents rocks metamorphosed to upper greenschist-lower amphibolite facies (Winkler 1979). Members are medium grained as they are extensively recrystallized and metamorphic plagioclase is well to poorly developed. Amphibole (most likely hornblende) usually occurs as euhedral porphyroblasts or with trains of inclusions aligned parallel to foliation. Biotite, garnet and the development of titanite after magnetite are common accessory minerals indicative of higher metamorphic grade. In conjunction with development of the higher grade minerals, chlorite and carbonate tend to decrease in abundance in these rocks. The most highly metamorphosed mafic matavolcanics in central Hartman Township contain a simple mineral assemblage of plagioclase (An_{36}) + quartz + hornblende + titanite ± biotite.

Tourmaline is a common accessory mineral in the mafic metavolcanics and in a few locations pervasive tourmalinization has occurred. In these rocks, tourmaline comprises up to 40 percent of the minerals and occurs as rosettes radiating from a common centre. Many of the larger crystals are poikiloblastic with amphibole needles. The poikiloblastesis is interpreted as post-kinematic growth during regional hydrothermal alteration. In some places, tourmaline is accompanied by carbonate and quartz in original pore space in mafic pyroclastic rocks.

HORNBLENDE-PHYRIC MAFIC AND INTERMEDIATE METAVOLCANICS

Hornblende-phyric mafic and intermediate metavolcanics underlie the central part of Laval Township between Beartrack, Gardnar and Troutfly lakes and occur on numerous islands and along the east shore of Rafter Lake. These rocks are characterized by euhedral hornblende crystals from 1 mm to 1 cm in size that comprise up to 25 percent of the rock (Photo 5). In thin section hornblende is observed to have pseudomorphed clinopyroxene with crystals retaining sim-

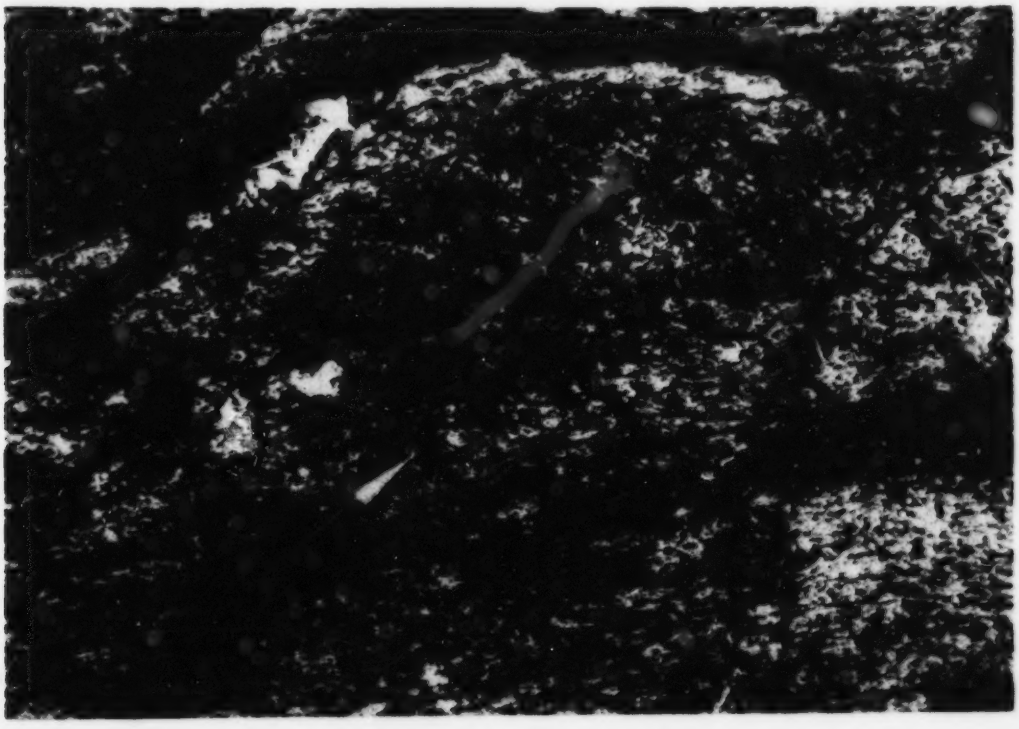


Photo 5. *Euhedral hornblende/pyroxene (at pencil tip) and plagioclase phenocrysts are characteristic minerals of formation B rocks in the Neepawa Group. (Pyroclast in lapilli tuff breccia on Rafter Lake. Pencil is 12 cm long.)*

ple and polysynthetic pyroxene twinning. Biotite aggregates commonly replace hornblende which is attributed to an increase in metamorphic grade, although potassium metasomatism does occur locally. Plagioclase laths, up to 5 mm, commonly accompany the hornblende phenocrysts and in a few places only plagioclase phenocrysts are apparent in the rocks. Where this occurs the plagioclase laths are usually aligned imparting a trachytic texture to the rock. The plagioclase alignment is not always parallel to foliation and in some pyroclasts is at an acute angle to foliation suggesting the trachytic texture may be primary.

The hornblende-phyric suite is composed predominantly of heterolithic pyroclastic deposits and minor massive and pillowed flows. The rocks generally weather grey-green and may have a sheen depending upon the amount of biotite in the rock. The majority of the rocks including pyroclasts are porphyritic and only the most basaltic members are fine grained, equigranular.

Massive flows are most common south of Beartrack Lake in close proximity to a diorite pluton. In one place a dike emanating from the pluton was observed to become autobrecciated and grade into a trachytic textured massive flow. This indicates the pluton is a subvolcanic intrusion that locally supplied magma to the metavolcanic suite. Most massive flows are fine- to medium-grained, grey-green rocks that are trachytic textured to hornblende phyric. For the most part flows contain small vesicles and amygdules comprising less than 5 percent of the rock. Flows are generally less than 20 m thick; however, they may be laterally extensive up to 700 m along strike.

Pillowed flows were observed on Rafter Lake where one flow sequence was traced for 400 m and averaged 25 m thick. Pillows are vesicular, well formed with thin to thick rims (0.5 to 1.5 cm) and average 1 m by 0.3 m in size. Pillows vary from being close packed to containing up to 20 percent interpillow material and at least one pillowed flow grades into pillow breccia. Pyroclastic deposits occur on either side of the pillowed flows indicating the flows are subordinate in this environment.

Pyroclastic deposits comprise the bulk of the hornblende-phyric suite and tuff, crystal tuff, lapilli tuff, lapillistone, breccia and tuff breccia are present. Tuff occurs throughout the sequence and is generally dark green, foliated with a granular texture as opposed to flows which are more crystalline. Crystal tuff is similar to tuff except feldspar crystals are more apparent on weathered surface and occasionally broken hornblende crystals are present. These rocks are green to grey-green and may contain coarse ash fragments (1 to 3 mm) whereas tuff are generally finer grained.

Lapilli tuff is common throughout the hornblende-phyric suite whereas lapillistone is common only at Rafter Lake. Both rock types are heterolithic with basaltic, trachytic and dacitic clasts most abundant. The clasts average 5 cm in size. Hornblende phenocrysts generally occur in both matrix and clast; however, in the transition from mafic metavolcanics (formation A, Neepawa Group) to the hornblende-phyric suite, it is common to find lapilli tuffs with hornblende-phyric clasts in an aphyric matrix or vice versa.

In the Beartrack Lake area, lapilli tuffs are unsorted, ungraded and poorly stratified. Clasts of various compositions are mixed together and lapilli tuffs are commonly interlayered with tuff breccia. Clasts of basaltic scoria are common as are angular trachytic and andesitic clasts and all deposits are clast supported.

At Rafter Lake lapilli tuff and lapillistone are well sorted, with graded stratification and commonly have laminated to finely bedded tuffaceous tops. Highly amygdaloidal andesitic pumice is common but basaltic scoria is absent (Photo 6). One lapillistone deposit contains only subangular to subrounded dacitic fragments in a hornblende-phyric matrix and most likely indicates winnowing of the more mafic clasts. Lapilli tuffs and lapillistones commonly contain more rounded fragments at Rafter Lake than at Beartrack Lake and in some deposits only rounded fragments occur. Bedding is well defined at Rafter Lake and lapilli deposits may vary from a few centimetres at the top of breccia units to individual beds up to 3 m thick. Almost all of these deposits are normally graded and always show stratigraphy younging to the south. Reverse grading of pumice was not positively identified; however, large rounded, highly amygdaloidal andesitic pumice (up to 30 cm) occur as isolated blocks near the tops of several deposits (Photo 6).

Breccia and tuff breccia comprise the predominant rock type at Beartrack and Troutfly lakes and occur in approximately equal volumes with other pyroclastic deposits at Rafter Lake. In the Beartrack–Troutfly lakes area, breccias and tuff breccias are unsorted, ungraded and unstratified. Clasts average 15 to 20 cm in size with maximum of up to 1.5 m observed. Clasts range in composition from basalt, andesite, trachytic andesite, dacite and diorite and commonly all clast compositions are mixed together in a clast-supported matrix. A particularly good outcrop on the west shore of Beartrack Lake near the Graham Bousquet No. 1 gold showing displays all of these features and shows clasts ranging from subrounded to angular (Photo 7). Debris flows are interpreted to be the main mode of deposition of all of these deposits. Euhedral hornblende phenocrysts occur in the matrix and clasts of these deposits and locally are very dense (up to 25 percent). For the most part, these rocks appear to have been rapidly deposited or dumped in place. The high proportion of scoriaceous and pumaceous fragments indicates a shallow water to subaerial eruptive environment; however, the general lack of vesicles and amygdules in the associated hornblende-phyric flows indicates a deep water depositional environment.

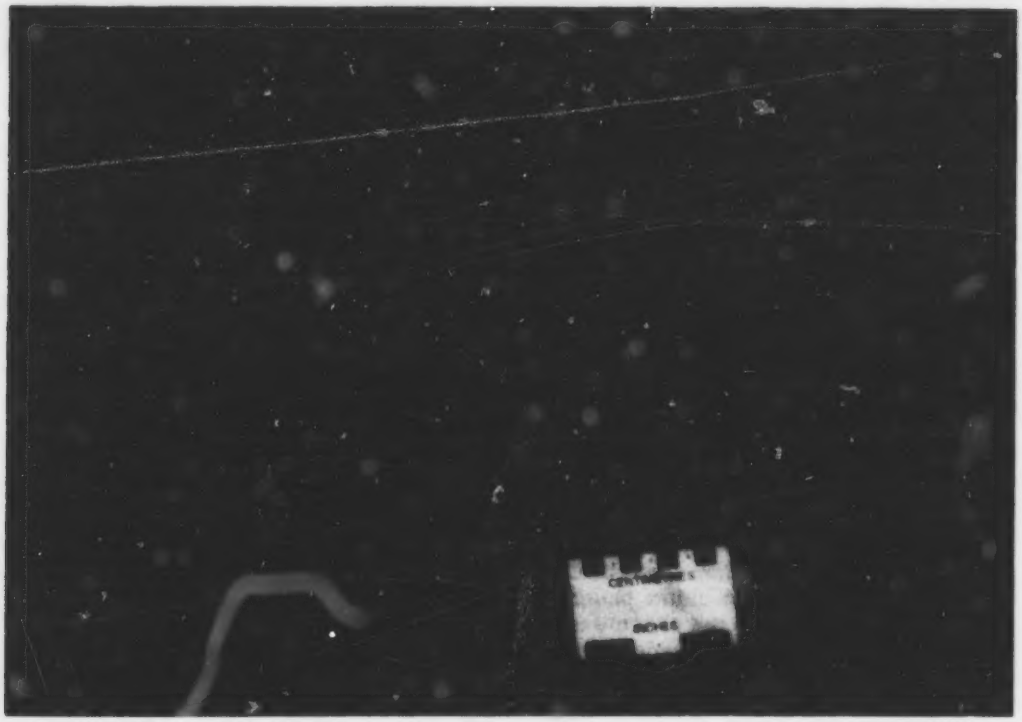


Photo 6. *Large, isolated pumice block in well-bedded hornblende-phyric tuff on Rafter Lake. Formation B, Neepawa Group.*

Photo 7. *Heterolithic pyroclastic rocks at Beartrack Lake are typical deposits of formation B, Neepawa Group, and are interpreted as debris flows.*

At Rafter Lake the breccias and tuff breccias are poorly to moderately sorted, with graded stratification. Clasts are generally rounded and composed of hornblende-phyric andesites or trachytic andesites with locally abundant andesitic pumice. Dacite fragments are uncommon and generally restricted to one breccia unit along the southeast shore although a few blocks do occur elsewhere. Clasts up to 1 m were observed although most clasts average between 15 to 20 cm. Breccia units up to 5 m thick are present although most are thinner and a lot of units grade upward into laminated tuff or lapilli tuff units. Grading of lithic clasts is common and stratigraphic tops are always to the south. The better sorting, grading and stratification of these deposits indicates a greater amount of reworking has affected these rocks than the rocks at Beartrack Lake and therefore are interpreted to be deposited distal to their source. The pyroclastic rocks at Beartrack Lake are more proximal to their source which is interpreted from mapping by Chorlton (1986, 1987) to be in the Goldlund Mine area where vent facies deposits and abundant basaltic scoria occur.

Where members of the hornblende-phyric suite have been sheared chlorite schists are developed. These rocks are dark green and fissile to indurated with trace amounts of sulphides on the slip faces. They do not retain hornblende phenocrysts or any identifiable primary feature and are distinguished from mafic metavolcanic schists only by association with clearly identifiable hornblende-phyric rocks.

Basaltic dikes and sills cut the hornblende-phyric rocks on Beartrack Lake near the diorite subvolcanic pluton. These dikes and sills are a few centimetres to 2 m wide and exhibit chilled margins and bright green aphanitic to fine-grained groundmasses. Rarely small millimetre-sized hornblende phenocrysts are present which serve to distinguish these dikes and sills as hornblende phyric.

The hornblende-phyric metavolcanic suite is correlated with the Neepawa Group and has been assigned formational status by the author. This suite is called formation B and clearly overlies formation A at Rafter Lake. Here south-facing metavolcanics of formation A are in sharp contact with southward graded hornblende-phyric tuff breccias and lapilli tuffs. West of Gardnar Lake, the contact between formation A and formation B is transitional with hornblende-aphyric units intercalated with hornblende-phyric units. In the Beartrack Lake area, the transition from formation A to formation B is fairly rapid, although intrusion of the diorite subvolcanic pluton along this interface complicates interpretation. South of Troutfly Lake, the contact is abrupt with hornblende-phyric pyroclastic rocks adjacent to aphyric pillowed basalts. The actual contact is sheared and the two formations may be structurally juxtaposed. It appears that there was a fairly rapid transition between the two formations and no accumulation of clastic metasediments occurred between the two formations.

Rocks similar to formation B occur along strike in McAree Township (Berger 1989), along strike in Echo Township (Chorlton 1987) and are reported to occur in the Sioux Lookout area (Page and Clifford 1977; Trowell et al. 1983). Trowell (in preparation) reports that rocks, similar to formation B in the Sioux Lookout area are calc-alkalic basalts and andesites, and based on chemical, textural, structural and morphological features are comparable to modern-day andesitic stratovolcanoes. These rocks are the youngest in the Neepawa Group and were named the Northeast Bay formation (Trowell, in preparation).

Pyroxene and plagioclase-phyric rocks have been noted elsewhere in the western Wabigoon Subprovince. Trowell (1986) observed clinopyroxene-phyric pillowed and massive flows in the Gibi Lake area south of Kenora, Ontario. Ayer et al. (1987) and Morrice and MacMaster (1987) have mapped pyroxene-phyric mafic, intermediate and felsic metavolcanics in the Lake of the Woods area. The latter have mapped extensive areas of these metavolcanics and their data indicate the rocks represent an Archean alkalic suite erupted in a shallow water or subaerial environment (Morrice and MacMaster 1987). The pyroxene-phyric metavolcanics conformably overlie an older mafic tholeiitic suite and are similar in morphology and chemistry to other Archean shoshonitic suites (Morrice and MacMaster 1987).

Geochemical data derived from hornblende-phyric rocks in the map area indicate the rocks are tholeiitic to calc-alkalic rather than alkalic. This is more thoroughly discussed under Geochemistry (*see* below).

Petrographic Summary of the Hornblende-phyric Metavolcanics

The hornblende-phyric mafic and intermediate metavolcanics contain the following typical mineral assemblage:

1. Plagioclase (An_{26-32}) + epidote + hornblende + quartz ± chlorite ± carbonate.

Almost all examined thin sections of hornblende-phyric rocks contain euhedral plagioclase and/or brown-green hornblende or less commonly relict clinopyroxene. In some thin sections, plagioclase is completely converted to epidote but in many rocks, plagioclase is well preserved and optical determinations indicate a very narrow compositional range between An_{26} to An_{32}. Relict clinopyroxene phenocrysts were observed in a few thin sections; however, where alteration and metamorphism are more pronounced, the phenocrysts are converted to either chlorite and amphibole or to biotite aggregates. Epidote is ubiquitous and commonly occurs as small anhedral grains in the matrix or groundmass or within plagioclase grains. Quartz is commonly a secondary mineral sited within amygdules and rarely makes up part of the framework mineralogy. Chlorite is common and is generally an anomalous brown-grey co-

lour indicative of high magnesium content (Deer, Howie and Zussman 1971). It typically occurs as fine blades in the matrix or replaces original mafic minerals presumably clinopyroxene or hornblende.

Primary textures are well preserved in this metavolcanic suite and the predominant porphyritic texture indicates these rocks were originally calc-alkalic andesite, basalt and trachyandesite analogous to modern-day counterparts. The development of biotite as a common secondary mineral indicates elevated potassium and this is interpreted to reflect primary chemistry as mafic aphyric metavolcanics in contact or intercalated with these rocks seldom contain biotite. The implication is that the hornblende-phyric rocks are calc-alkalic and were produced in an environment analogous to modern-day back-arc volcanism (M.G. Morrice, Ontario Geological Survey, personal communication, 1987).

FELSIC TO INTERMEDIATE METAVOLCANICS

Felsic to intermediate metavolcanics occur as narrow continuous to discontinuous units within formation A of the Neepawa Group and are interbedded within the Minnitaki and Abram metasedimentary groups. Felsic to intermediate metavolcanics comprise no more than 5 percent of the supracrustal rocks. For descriptive purposes in this report, feldspar- and quartz-feldspar-phyric dikes are included within the felsic metavolcanics because for the most part these rocks are spatially related to felsic metavolcanics and the groundmass of the dikes is generally fine grained with similar mineralogy to the felsic metavolcanics.

For the most part, felsic to intermediate metavolcanics within formation A of the Neepawa Group are composed of massive to spherulitic flows with subordinate pyroclastic units. Flows are light grey, white and black weathering and are commonly aphanitic to very fine grained. Massive flows are featureless to flow laminated with small millimetre-sized quartz filled amygdules and contain small (1 to 2 mm) hornblende or biotite porphyroblasts. Flows are generally less than 3 m thick and are commonly interlayered with spherulitic flows and felsic tuff or crystal tuff.

Spherulitic flows are commonly dark grey, white or black weathering. White to black oval spherulites (1 mm to 1 cm) occur in an aphanitic groundmass and are arranged randomly or less commonly in discrete layers a few spherulites thick. Layers composed of totally coalesced spherulites were observed west and south of Gardnar Lake and here the flows show a transition from a massive or sparsely spherulitic portion into a densely spherulitic to totally coalesced portion (Photo 4). Spherulites are generally massive and show no internal structures. In thin section spherulites are composed almost entirely of cryptocrystalline quartz with minor biotite, hornblende and muscovite, and no radial symmetry was detected.

Spherulites were observed in a felsic flow breccia in diamond-drill core (Hollinger Mines Limited, LB-1-478 395 feet) and here individual spherulites contained several radiating fans of crystals marked by graphitic inclusions which were interpreted as devitrification textures (cf. Thurston 1977). This type of felsic spherulitic flow occurs exclusively with other felsic metavolcanics. Variolites were not observed in contact or near these flows.

Another type of felsic spherulitic flow does occur with variolites and this type has been described above. Felsic spherulites in a mafic groundmass are observed in several places to gradationally pass into felsic spherulites in a felsic groundmass. At one locality 1500 m northwest of Diamond Lake, a series of this type of flow, 60 cm to 2 m thick, was observed and each flow has a mafic portion in which spherulites comprise 40 to 50 percent of the rock. The spherulites increase in density until they comprise 90 to 100 percent of the rock and are coalesced into a single layer. This type of felsic flow is interpreted to have formed by immiscible liquid splitting (*see* above).

Felsic pyroclastic rocks are subordinate to flows in formation A of the Neepawa Group and are predominantly tuff and crystal tuff. These rocks are grey to white and most commonly seen in Hollinger Mines Limited diamond-drill core stored in Kenora. The rocks are fine grained and generally more granular textured than flows. They form discontinuous units and are never very abundant.

Felsic flow breccia that occurs within formation A of the Neepawa Group is characterized by angular to rounded rhyolitic to dacitic fragments in a mafic to felsic matrix. At Rafter Lake, rounded dacitic fragments in a dacitic matrix appear to have resulted from auto-brecciation. However, dacitic and rhyolitic fragments in a mafic matrix along the Diamond Lake road appear to have been partially assimilated by the matrix as well as mechanically fragmented. The origin of this texture is not know; however, magma mixing may have been involved (*see* below).

Felsic metavolcanics occur along the contact of the Neepawa and Minnitaki groups and as units within both the Minnitaki and Abram groups. Along the Neepawa–Minnitaki contact, tuff and lapilli tuff with subordinate spherulitic flows and breccia occur as discontinuous units up to 300 m wide by 1200 m long. These rocks are grey to white, generally quartz aphyric and generally well sorted and well stratified. Graded bedding was observed in a few places and most coarser deposits are monolithic to heterolithic with a predominance of rounded fragments. A number of gas cavities in fragments, quartz-filled amygdules and what appear to be pisolites occur within these units. All this indicates a relatively shallow water eruptive environment; however, there also appears to have been a fair amount of reworking of these rocks and they were most likely deposited in relatively deep water distal to their source. Stratigraphy youngs to the southeast as determined by graded bedding and these felsic metavolcanics conformably overlie mafic metavolcanics of formation A of the

Neepawa Group. The felsic metavolcanics become intercalated with wacke beds up to 1 m thick within 100 m of the upper contact and gradually clastic and chemical metasediments of the Minnitaki Group become dominant. These felsic metavolcanics are included within formation A of the Neepawa Group and based on similar mineralogy and similar stratigraphic position are correlated with felsic metavolcanics in McAree Township which have also been correlated with the Neepawa Group (Berger et al. 1989a, 1989b).

Felsic metavolcanics occur as single beds and as mappable units within the Minnitaki and Abram metasedimentary groups. The majority of these felsic rocks are tuff and crystal tuff; however, subordinate lapilli tuff, tuff breccia and quartz-muscovite schist are present. Tuff and crystal tuff beds are white to buff which makes them easy to identify as the clastic metasediments are generally darker coloured. The felsic interbeds are commonly more crystalline and massive than wacke although thicker units (over 15 cm) may be laminated or graded. The tuffaceous rocks are generally 5 to 8 cm thick and occur as single interbeds between wacke, most commonly in the Abram Group in northwest Laval Township. Multiple tuff beds in units up to 20 m thick are common in the Minnitaki Group northwest of Laval Lake and one thick unit (up to 400 m) of laminated tuff and quartz muscovite schist was traced over 3500 m along the shores of Laval Lake.

Lapilli tuff and tuff breccia units were observed in a couple of places within the Abram Group. The clasts are rounded, poorly to well sorted, are generally matrix supported and dacitic in composition. The matrix of these deposits is highly quartzofeldspathic with a high degree of crystallinity which serves to distinguish these rocks from metasedimentary conglomerates.

Where felsic metavolcanics are highly deformed, quartz-muscovite schist is developed. These rocks are white to straw yellow, schistose, commonly with quartz and garnet porphyroblasts and clots. They are most common on Laval Lake where they are interlayered with tuff and crystal tuff.

Rocks mapped as quartz porphyry occur in northwestern Hartman Township and are characterized by small quartz crystals, 0.5 to 1 mm in size, in a highly recrystallized matrix. Lapilli tuff interbedded with wacke occurs nearby and most likely the quartz porphyritic rocks are highly metamorphosed equivalents of the lapilli tuff.

Feldspar- and quartz-feldspar-phyric dikes intrude all supracrustal rocks in the map area. These rocks are grey to white, fine to medium grained and occur as dikes from 15 cm to 25 m wide. They are equigranular to porphyritic with up to 25 percent biotite and hornblende in the groundmass. The distinction between feldspar and quartz-feldspar-phyric dikes is based on whether the rock contained more than 5 percent quartz phenocrysts as determined in the field. Based on mineralogy and spatial proximity, these dikes are interpreted to be related to felsic metavolcanics.

Petrographic Summary of the Felsic to Intermediate Metavolcanics

Felsic to intermediate metavolcanics are characterized by the mineral assemblage:

1. Quartz + plagioclase (An_{24-34}) + chlorite ± biotite ± amphibole ± epidote ± muscovite. Garnet, carbonate and microcline porphyroblasts are present in a few samples. Amphibole and garnet occur in highly metamorphosed intermediate members of this suite; whereas, muscovite and microcline occur in the more felsic members.

Many flows are porphyritic with subhedral to euhedral plagioclase phenocrysts in very fine grained to cryptocrystalline groundmasses. Spherulitic flows are characterized by cryptocrystalline quartz and plagioclase spherulites in a fine-grained groundmass. Mafic minerals and magnetite commonly cluster around the edges of spherulites and rarely form aggregates in the cores.

Tuff, schist and the matrices of coarse pyroclastic rocks are fine-grained equigranular and quartzofeldspathic. These rocks are largely recrystallized with platey minerals showing a strong preferred orientation and original textures are largely destroyed. Commonly garnet porphyroblasts and less commonly microcline porphyroblasts are present in units interbedded within metasediments and these minerals indicate upper greenschist to amphibolite metamorphism (Winkler 1979).

CLASTIC AND CHEMICAL METASEDIMENTS

Clastic and chemical metasediments underlie two separate portions of the map area. The largest area extends from north of Laval Lake through northwestern Hartman Township and includes thick metasedimentary units interlayered with mafic metavolcanics in central Hartman Township. Metasediments also underlie the northwest corner of Laval Township and occur as interlayered units within mafic metavolcanics north of Rafter Lake.

Wacke, siltstone and derived schists form the bulk of the metasedimentary units with minor but locally important units of sulphide-magnetite ironstone, chert, metatexite and hornblende-garnet amphibolite. Wacke is used to describe fine- to medium-grained clastic metasediments that presumably originally were composed of sand grains with a large proportion of matrix. In this report wackes have been subdivided into quartzofeldspathic wacke, mafic wacke and pebbly wacke.

Quartzofeldspathic wacke comprise the bulk of the metasediments in both areas. In the Laval Lake–Hartman Township area, wackes are grey to brown and laminated to thickly bedded (up to 1 m). Prima-

ry structures are poorly preserved in these rocks with massive to graded bedding being the only features observed. Numerous reversals in stratigraphic tops as determined from graded beds indicate the metasediments near Laval Lake are tightly folded and highly deformed. Garnet, staurolite and microcline porphyroblasts are developed in the more pelitic wackes and indicate amphibolite rank metamorphism has affected most of these rocks (Winkler 1979).

Wackes in northwest Laval Township are light grey to brown and laminated to medium bedded (up to 30 cm). Primary structures are better preserved than in the Laval Lake–Hartman Township area and massive to graded bed forms were observed as well as scour marks, "rip-up" clasts and small-scale cross stratification. In some of the wacke beds, grain gradation is overlain by parallel laminations which in turn is overlain by cross stratification with 1 to 2 cm foresets. This was interpreted as the A, B and C units, respectively, of the Bouma sequence and resulted from deposition of the sediments by turbidity currents (Walker 1976). In other beds, grain gradation is overlain by dark grey siltstone (AE turbidites) or grain gradation is overlain by parallel laminations which in turn is overlain by dark grey siltstone (ABE turbidites, Walker 1976). Stratigraphy is overturned in this area with "tops" consistently facing northwest and strata consistently steeply dipping southeast.

Mafic wackes are clastic metasediments containing greater than 10 percent hornblende. These rocks are most abundant in the Laval Lake area where they are interlayered with mafic amphibolite. Here mafic wackes are thinly bedded with up to 75 percent hornblende and epidote and form a continuous unit extending for approximately 2500 m. The mafic wackes are interbedded with felsic tuff at the south end of Laval Lake and gradually become unrecognizable as they become more thoroughly mixed with quartzofeldspathic wacke. Elsewhere mafic wacke is interlayered with mafic amphibolite along the north contact of the Hartman Lake Stock. Here it is laminated and highly garnetiferous. Mafic wacke occurs in thin beds at several locations near the contact of the metasediments and formation A of the Neepawa Group and near the metasedimentary-mafic metavolcanic contact in northwest Laval Township. This spatial relationship suggests mafic wackes are derived by erosion of the mafic metavolcanics and their preservation resulted from rapid burial without being substantially reworked.

Pebbly wackes occur at only two locations in northwest Laval Township. At both locations, rounded to subangular quartz and lithic fragments up to 1 cm are matrix to clast supported in a sandy wacke. Several of the fragments are limonitic and the units are very thickly bedded with wacke interbeds. Similar units were observed by Berger et al. (1989a, 1989b) on the north shore of Sandybeach Lake in McAree Township within the Minnitaki Group, and it is suggested the pebbly wackes in both areas were deposited in a similar environment.

Siltstone is generally subordinate to wacke although locally it comprises more than 50 percent of the outcrop in both areas. Siltstones are dark grey to dark brown and are thinly bedded to laminated. Siltstones commonly overlie graded wacke units and in this setting are interpreted to represent the "E" division of the Bouma sequence of turbidite deposition (Walker 1976). The high proportion of siltstone to wacke in many outcrops suggests a low energy relatively deep water depositional environment (Walker 1976). Siltstones are more pelitic than wackes and where they are highly metamorphosed, porphyroblasts (0.3 to 1 cm) of staurolite and garnet are well developed. If porphyroblast density is sufficiently great enough, the turbidite unit may appear to be reversely metamorphic graded.

Schists are commonly developed throughout the clastic metasediments but tend to be more abundant in Hartman Township where greater deformation and a higher metamorphic grade occur. Two types of schists were recognized in the map area; namely, argillaceous to phyllitic schist and biotite-muscovite-quartz schist.

Argillaceous to phyllitic schist occurs only locally in the map area and is most abundant within Hollinger Mines Limited diamond-drill core and is interpreted from diamond-drill logs of other companies that have worked in the map area. These schists are dark grey to black, very fine grained and generally are foliated with finely spaced cleavage planes. For the most part these schists are fissile and graphitic. They are interpreted to have originally been mudstones and due to their low resistance to erosion are poorly exposed. Several airborne electromagnetic conductors may be coincident with these schists as their graphite and more rarely sulphide content is high (Ontario Geological Survey 1987a-f).

Biotite-muscovite-quartz schists are more common than argillaceous and phyllitic schists. These rocks are brown to grey, foliated to fissile and devoid of primary structures. They are common where metasediments are sheared as along the trace of the Wabigoon Fault and in several places, along the contact of the Neepawa Group with the metasediments. In several places up to 10 percent of the schist is composed of contorted quartz and granitic stringers which are interpreted to form by partial melting of the protolith. Graphite and sulphides (up to 25 percent) occur in biotite-muscovite-quartz schists in a few places along the southern contact of the Neepawa Group with the metasediments, however, as yet, no economic mineralization has been encountered by exploration companies (*see* Economic Geology).

Staurolite, garnet and less commonly microcline porphyroblasts are developed in these schists and indicate the relatively high grade of metamorphism that has affected these rocks.

Metasedimentary xenoliths are common within the granitic pegmatite in Laval Township. Some of these xenoliths are well preserved blocks up to 50 m square that retain primary bedding parallel to the regional northeast-striking third stage foliation. However, many metasedimentary blocks are migmatized and contain a grey to dark grey paleosome with 10 to 70 percent neosome. Biotitic melanosome occurs as thin wispy streaks or as discontinuous layers in some of the xenoliths and this indicates *in situ* partial melting occurred (Winkler 1979). The term metatexite (Brown 1973) can be used to describe these rocks. Commonly paleosome and neosome of the metatexite are banded parallel to the regional foliation and this is interpreted as a further indication of *in situ* melting of the granitic pegmatite.

Hornblende-garnet-biotite amphibolite is a minor but distinctive rock type in the map area. It is a dark green to black rock with 3 to 7 mm red garnets comprising up to 50 percent of the rock. Commonly up to 25 percent pyrite and pyrrhotite accompany the silicate minerals. There are no primary structures preserved and wherever this rock type was observed it is either interbedded with clastic metasediments or occurs as bedded units at the top of felsic flows near clastic metasediments. Hornblende-garnet-biotite amphibolite forms a laterally continuous unit for over 1500 m in McAree Township, east of the map area and here is associated with similar rock types in a similar environment (Berger 1989). For these reasons, hornblende-garnet-biotite amphibolite is included within the metasediments even though its mineralogy indicates a mafic metavolcanic source. The author speculates that this unit may have been derived from a rapidly buried mafic tuff that subsequently underwent hydrothermal alteration to produce a chemistry favourable to the development of ubiquitous garnet.

Chemical metasediments are subordinate to clastic metasediments and are composed of chert, sulphide-magnetite ironstone and magnetite ironstone. Chert is white or black, cryptocrystalline and massive to laminated. It occurs as discontinuous lenses and pods in interflow metasediments and as pods in hyaloclastite and interpillow material. Chert in this setting is most common on the northwest shore of Beartrack Lake near the transition from formation A to formation B of the Neepawa Group. Chert also occurs as laminae and thin beds between magnetite layers in magnetite ironstone. Here chert is white and forms continuous beds throughout the entire outcrop. Chert in this setting is most common along the northwestern boundary between Hartman and Zealand townships.

Magnetite ironstone occurs as contorted and folded units up to 3 m thick interbedded with wacke in northwestern Hartman Township. Magnetite layers from 1 mm to 5 cm thick comprise up to 50 percent of the units and are separated by chert layers of comparable thickness. Together they are highly contorted with evidence for at least two periods of deformation. These units are continuous with extensive magnetite ironstone units farther west in Zealand Township mapped by Satterly (1943). A large airborne magnetic high is coincident with the ironstone and several electromagnetic anomalies flanking the magnetic high suggest conductive material is associated with the ironstone (Ontario Geological Survey 1987c). Further, the airborne magnetic pattern describes a northeast-closing fold which structural data in the map area indicates is caused by the latest stage of deformation. Given the rather lean nature of the ironstone and large amount of interbedded wacke, these deposits do not appear to be commercially exploitable at present. Magnetite ironstone also occurs as discontinuous thin units (2 to 10 cm) interbedded within mafic metavolcanics of formation A of the Neepawa Group. Here magnetite beds are finely laminated to massive and are commonly found with metamorphic magnetite segregations which are also present. Small magnetite units near the Graham Bousquet's northern gold showing on Beartrack Lake are the best example of magnetite ironstone in this setting.

Sulphide-magnetite ironstones are schistose rocks containing minor amounts of magnetite and from 5 to 50 percent sulphides, principally pyrite. Where observed in outcrop and in diamond-drill core, sulphide-magnetite ironstones are narrow units, generally less than 10 m thick, are commonly graphitic, and are spatially restricted to metasediments at or near the contact with formation A of the Neepawa Group. These units appear to be formational in that they are bedded and appear to occur in approximately the same stratigraphic position throughout the map area. Similar units in McAree Township to the east of the map area are semicontinuous and serve as a marker horizon between Neepawa Group felsic metavolcanics and Minnitaki Group metasediments (Berger 1989). It appears that the sulphide-magnetite ironstones are the extension of similar units from McAree Township into the map area. The sulphide and graphite content of these rocks makes these units excellent conductors, and formational airborne electromagnetic anomalies along the metavolcanic-metasedimentary interface are attributed by the author to sulphide-magnetite ironstones (Ontario Geological Survey 1987b, 1987c). Exploration by mining companies along this horizon indicates pyrite and pyrrhotite are the most abundant sulphides encountered, however, chalcopyrite, sphalerite and galena occur in subeconomic quantities and subeconomic silver assays have been returned from diamond-drill results. Up to 0.70 percent combined copper and zinc and geochemically anomalous gold values were returned from sulphide occurrences sampled by the survey crew and this indicates sulphide-magnetite ironstones are prospective exploration targets (*see* Economic Geology).

The metasediments underlying Hartman Township and southeastern Laval Township are contiguous with metasediments in McAree and MacFie townships east of the map area. Here they have been correlated with the Minnitaki Group (Berger 1989) and

by extension the metasediments in the map area are correlated with the Minnitaki Group. Metasediments are intercalated with the Southern Volcanic Belt metavolcanics and occur along the northern contact of the Hartman Lake Stock. The latter metasediments are poorly bedded, highly deformed and partially migmatized. Similar rocks were observed south of the Sandybeach Lake Stock in MacFie Township (Berger et al. 1989a, 1989b) where they were clearly contiguous with less deformed and less metamorphosed Minnitaki Group metasediments. Based on the similarity in deformation, metamorphism and that they appear to be contiguous, the metasediments along the north contact of the Hartman Lake Stock are included in the Minnitaki Group.

Metasediments intercalated within the Southern Volcanic Belt mafic metavolcanics were designated the Zealand Sediments by Satterly (1943). These rocks are composed of quartzofeldspathic wackes and schists with very little locally derived mafic wacke. Based on their mineralogical and morphological similarity, the Zealand Sediments are correlated with the Minnitaki Group. Contacts with metavolcanics of the Southern Volcanic Belt metavolcanics are sheared and the geographic distribution of the metasediments is attributed to tectonic intercalation (Chorlton, in preparation).

The metasediments in northwestern Laval Township are known to extend northwest and southeast of the map area (Page 1984; Satterly 1943). Satterly (1943) referred to these rocks as the Brownridge Sediments and Page (1984) correlated the metasediments in his area with the Abram Group in the Sioux Lookout area. Turner and Walker (1973) subdivided the Abram Group into three formations, namely: the Ament Bay Formation, the Daredevil Formation and the Little Vermilion Formation, all of which are in the Lateral Lake area north of Laval Township (Page 1984).

The Ament Bay Formation is composed of conglomerate and arkose with the latter displaying trough cross-bedding with foresets up to 15 cm, parallel laminations, massive beds and pebble layers (Turner and Walker 1973). This formation has been interpreted as an alluvial fan deposit (Turner and Walker 1973).

The Daredevil Formation overlies the Ament Bay Formation and is composed of felsic and mafic tuff and "agglomerate" (Turner and Walker 1973). Units are massive, ungraded and poorly sorted with maximum size of felsic fragments up to 30 cm and of mafic fragments up to 1 m. Wacke is commonly interbedded with the metavolcanics (Turner and Walker 1973).

The Little Vermilion Formation overlies the Daredevil Formation and is composed of wacke and siltstone with massive and graded beds which are interpreted to result from deposition by turbidity currents (Turner and Walker 1973).

Page (1984) indicated that members of the Ament Bay Formation occur along the Laval–Webb Township boundary; however, along strike in the map area felsic tuff breccia, wacke and dark grey siltstone were observed. These lithologies are more compatible with the Daredevil and Little Vermilion formations and the author prefers to correlate the metasediments in northwestern Laval Township with these formations of the Abram Group. Metavolcanic and metasedimentary units are well mixed and intercalated and it appears formations as defined by Turner and Walker (1973) may no longer be recognizable in the map area.

Further, there is a striking similarity between the morphology and mineralogy of the Abram and Minnitaki groups in the map area. Distal facies turbiditic wacke and siltstone are the dominant lithologies in both groups. Pebbly wackes that contain distinctive limonite and quartz pebbles form minor but important units in both groups. Felsic metavolcanics are interbedded in the Abram and Minnitaki groups and locally are voluminous enough to form mappable units in both groups. These deposits are morphologically and mineralogically similar in the map area and only the geographic separation and greater deformation in the Minnitaki Group serve to distinguish the two groups in the map area. Based on these observations the author concludes that the Abram and Minnitaki groups are equivalent in the map area. Johnston (1969), Trowell et al. (1980) and Trowell (in preparation) inferred that the Minnitaki Group was equivalent to the Abram Group and Trowell (in preparation) concludes that differences between the two groups can be explained as lateral and vertical facies changes.

The stratigraphic column for the Sioux Lookout area proposed by Turner and Walker (1973) differs from that proposed by Trowell et al. (1980) with respect to the positions of the Neepawa (Central Volcanic Belt), Abram and Minnitaki groups. This problem is fundamental to understanding the evolution of the supracrustal rocks in this area and future work should be directed towards gathering absolute ages, supported by detailed field observations on stratigraphic and especially structural relationships between groups.

Petrographic Summary of the Clastic and Chemical Metasediments

Most clastic metasediments are characterized by the mineral assemblage:

1. Quartz + biotite + muscovite ± plagioclase ± chlorite ± garnet ± staurolite ± cordierite.

Tourmaline is the most common accessory mineral and carbonate, titanite, zircon, apatite and epidote are present in trace amounts. Microcline porphyroblasts were identified in wackes adjacent to granitic pegmatite intrusions and indicate middle amphibolite rank metamorphism (Winkler 1979).

Mafic wacke is characterized by the mineral assemblage:

2. Quartz + hornblende + epidote ± garnet ± biotite ± plagioclase.

Hornblende-garnet-biotite amphibolite occurs only locally and its mineralogy clearly reflects a mafic igneous origin:

3. Hornblende + talc + garnet + chlorite + epidote ± biotite.

Chemical metasediments were not examined petrographically because of the cryptocrystalline nature of chert and the large proportion of opaque minerals in the ironstones.

Mineral assemblage 1 applies to wacke, siltstone and their derived schists. Quartz, biotite and muscovite is present in all these rocks in amounts varying from trace (for muscovite) up to 60 percent (for quartz). Staurolite occurs in the most muscovitic rocks, whereas garnet and cordierite are best developed in muscovite-poor rocks. Chlorite occurs in a number of rocks and appears to have been produced by oxidation of the biotite through weathering or occurs as garnet pseudomorphs and around the rims of altered staurolite crystals. Plagioclase was positively identified in a few rocks, however, it may occur as small grains in the matrices of most clastic metasediments. Optical determination of anorthite content was not possible due to small grain size and poor preservation of twinning. Staurolite porphyroblasts are common and are recognized in thin sections as dense fibrous mats of secondary muscovite intergrown and surrounded by quartz and less commonly chlorite. Rarely a second generation of idioblastic muscovite has overgrown the mats and this is interpreted as crystal growth during a second prograde metamorphic episode. Garnet occurs in biotitic rocks or muscovite-poor layers in otherwise muscovitic rocks. Anhedral to subhedral helicitic to massive crystals are common and in a few rocks chlorite pseudomorphs retain garnet crystal forms indicating retrograde metamorphism of these areas.

Staurolite, cordierite and porphyroblastic microcline in these quartzofeldspathic to pelitic metasediments indicates amphibolite grade metamorphism (Winkler 1979). Nowhere in the map area were metasediments encountered that did not contain at least one of these minerals. In the area east of Laval and Hartman townships, similar minerals were observed in metasediments as well as andalusite and sillimanite (Berger 1989). Temperatures adjacent to the Sandybeach Lake Stock were estimated to range between 550° and 650°C (at pressures between 2.5 and 3 kbar (Berger 1989). These conditions are sufficient to allow anatexis to begin and the white granitic pegmatites in both areas indicate this occurred (Berger 1989).

Phyllosilicates in all metasediments show a strong fabric anisotropy which is attributed to crystal growth during deformation and metamorphism. All metasediments are recrystallized and original sedimentary structures and fabrics are largely destroyed. Only bedding which is distinguished by alternating phyllosilicate rich and poor layers can be recognized macroscopically. For the most part, only one deformation is recognized in thin section; however, second generation porphyroblasts, crenulated cleavages and retrograde metamorphic minerals indicate multiple periods of deformation and metamorphism have affected all metasediments.

MAFIC INTRUSIVE ROCKS

Mafic intrusions occur in the Southern Volcanic Belt and the Neepawa Group and are composed of gabbro, diorite, plagioclase-phyric gabbro, quartz diorite and a pervasively silicified albitized, carbonitized and pyritized rock referred to as altered gabbro. For the purpose of this report, mafic rocks with a phaneritic texture that contain no obvious flow features (i.e., pillows, pillow breccia or flow breccia) were mapped as intrusions. For the most part, this definition is acceptable as chilled contacts and xenoliths were observed in many of the outcrops mapped as intrusions. However, some intrusions changed along strike into fine-grained flow-like rocks and in the Beartrack Lake area diorite dikes were observed to pass into andesitic flows containing amygdules. The absence of definitive intrusive relationships in many areas makes the separation of intrusion from flow very difficult. Based on these observations, the mafic intrusions in the map area and especially in the Beartrack Lake area are interpreted to be subvolcanic in origin.

"Gabbro" and "diorite" are used as field terms and gabbro refers to a melanocratic, medium- to coarse-grained rock, whereas diorite is used to describe rocks that are feldspathic (20 to 50 percent). In thin sections, however, anorthite content in plagioclase is consistently less than An_{50} and primary quartz is almost always present. This indicates the rocks are diorites (Streckeisen 1976).

Gabbros comprise the bulk of the mafic intrusive rocks and are typically dark green to black, medium to coarse grained and equigranular to porphyritic. Generally these rocks are highly recrystallized with a secondary mineral assemblage of amphibole, epidote, chlorite and carbonate replacing primary mafic minerals and plagioclase. Subophitic textures are rarely preserved and commonly these rocks are equigranular. Southwest and east of Troutfly Lake, phases of gabbroic sills contain round aggregates of amphibole crystals up to 1 cm in diameter. These aggregates appear to be primary as they can be traced laterally along strike and appear to always occur near the base of the sills.

Plagioclase-phyric gabbro is common within formation A of the Neepawa Group. White euhedral plagioclase phenocrysts up to 3 cm in diameter occur in a green to dark green phaneritic groundmass and vary from 15 to 70 percent of the rock. In one sill south of

Diamond Lake, plagioclase content was observed to increase from approximately 20 to 25 percent to 50 percent going from the base towards the top of the intrusion. Phenocryst content abruptly dropped to 15 to 20 percent then gradually increased again within the same intrusion. This is interpreted as resulting from multiple injection of magma. Commonly the plagioclase crystals are concentrically zoned and this is interpreted as resulting from a long and complex history of formation within a magma chamber. Green (1975) concluded that plagioclase phenocryst formation in Archean glomeroporphyritic mafic rocks required a lengthy resident time in the magma chamber. Further, Green (1975) noted that these types of glomeroporphyritic rocks most commonly were found within 300 m of the contact between tholeiitic and calc-alkalic metavolcanics. In the map area, plagioclase-phyric gabbro within formation A of the Neepawa Group is most abundant within 300 m of formation B of the Neepawa Group which is calc-alkalic (*see* Geochemistry) and this supports Green's (1975) observations.

Leucogabbro-leucodiorite is spatially restricted to a mafic pluton in the Beartrack Lake area. This rock is coarse grained, equigranular with a colour index greater than 50. It has a subophitic texture, contains up to 75 percent andesine plagioclase and less than 2 percent interstitial quartz. It is most common along the northwest shore of Beartrack Lake and grades into more melanocratic diorite around the periphery of the stock.

The stock on Beartrack Lake is composed largely of diorite and has intruded along the contact between formation A and formation B of the Neepawa Group. Several gabbroic dikes and sills that clearly originate from this pluton intrude formation B metavolcanics and one of the larger dikes was observed to grade from phaneritic diorite into aphanitic, amygdaloidal andesite. This indicates the pluton is subvolcanic and was a source for at least some of metavolcanics of formation B. This pluton is economically significant as two gold showings are spatially associated with it.

Quartz diorite occurs as dikes and small irregular intrusions west of Beartrack Lake. The largest of these bodies has intruded the diorite pluton and occurs as east-northeast-striking dikes approximately 300 m west of Beartrack Lake. At Beartrack Lake, the quartz diorite is grey, medium grained and equigranular with up to 20 percent quartz and less than 10 percent mafic minerals. In this area, extensive quartz veining and tourmalinization accompanies erratic pyrite and scheelite mineralization. Gold assays up to 230 ppb have been returned from selected grab samples and indicates this area is potentially economic (*see* Economic Geology). It is possible the quartz diorite is a late felsic phase of the diorite pluton, however, Chorlton (1987) has observed similar quartz diorite-tonalite dikes intruding the Neepawa and Minnitaki groups northeast of the map area.

Southwest of Troutfly Lake, "altered gabbro" occurs in a number of places and is always associated with unaltered gabbro-diorite sills and dikes. "Altered gabbro" is so named because it is a grey, pink or white weathering rock that has been silicified, carbonatized, albitized and contains various amounts of pyrite, ilmenite and less commonly gold. This rock is medium grained, equigranular and occurs at the Goldlund Mine in Echo Township where it has been referred to as granodiorite by the previous mine operators and as albite trondjhemite by Page (1984). In thin section, the rock is characterized by a distinctive texture of radial aggregates of symplectic albite and quartz. The overall texture resembles that of granophyre and careful examination indicates that many of the aggregates are overprinting earlier crystallized quartz or plagioclase. In other samples, albite and quartz intergrowths rim euhedral plagioclase crystals and appear to be a late stage crystallization or exsolution feature.

The "altered gabbro" exhibits complex field relationships with the surrounding rocks. In many places, it gradationally passes along and across strike into melanocratic gabbro. At the south end of Troutfly Lake, the "altered gabbro" is chilled against a melanocratic metagabbro and this indicates that here the two rock types are separate intrusions (Chorlton 1987). The "altered gabbro" also shows a close spatial relationship with felsic spherulitic rocks. At the south end of Troutfly Lake, spherulitic flows and fragmental rocks occur along the structural footwall with the "altered gabbro" and in several places southwest of Troutfly Lake spherulitic flows are in contact with the "altered gabbro". In one diamond-drill hole of Hollinger Mines Limited west of Diamond Lake, "altered gabbro" was logged as rhyolitic lapilli (up to 12 mm long) in an andesitic, moderately magnetic matrix and was gradational into spherulitic and tuffaceous rhyolitic rocks. A sample of this material collected and thin sectioned by the author was mottled grey and green with grey spherical aggregates of albite and quartz in a chloritic and biotitic groundmass. In this setting, there appears to be a genetic relationship between the "altered gabbro" and the felsic flows and tuffs.

The "altered gabbro" is an economically important rock type in the map area. Gold is hosted by "altered gabbro" at the south end of Troutfly Lake and it occurs in the Goldlund Mine northeast of the map area. The "altered gabbro" has been encountered on surface or in diamond-drill holes in a more or less continuous stratigraphic unit from the Goldlund Mine to west of Diamond Lake and has been the main gold exploration target. Hollinger Mines Limited diamond-drill holes tested electromagnetic conductors for their lead-zinc-silver potential and encountered subeconomic mineralization associated with felsic metavolcanics and the "altered gabbro" (*see* above). Galena and sphalerite in quartz veins have been observed by exploration personnel and the present survey crew at several locations in the "altered gabbro"

in the map area. This indicates the potential for base metal mineralization in this rock.

The origin of the "altered gabbro" remains problematic. It is possibly a felsic differentiate from a gabbroic magma. Geochemical analyses indicate there is a chemical affinity between the felsic spherulitic flows and the "altered gabbro" (*see* Geochemistry). L.B. Chorlton (Ontario Geological Survey, personal communications, 1987) speculates the chemistry and microscopic textures may originate through immiscible liquid splitting, and based on the textures within the variolite-spherulite units (*see* above) the author agrees with this inference. However, much further field and laboratory work is required to resolve this problem.

FELSIC INTRUSIVE ROCKS

Four felsic plutons and a suite of granitic pegmatite and aplite have intruded the supracrustal rocks in the map area. The felsic plutons are spatially separated and are referred to as the Hartman Lake Stock, the Sandybeach Lake Stock, the Gardnar Lake Stock and the Crossecho Lake Stock. All plutons have been deformed and metamorphosed although most have retained their original mineralogy and less commonly original textures.

Hartman Lake Stock

The Hartman Lake Stock underlies the southern part of Hartman Township and has intruded members of the Southern Volcanic Belt and the Minnitaki Group. The intrusion consists of three main phases and related dikes, sills and intrusion breccias. The main phase forming approximately 85 percent of the pluton is pink, medium- to coarse-grained, equigranular to slightly porphyritic granodiorite. Green biotite is the main mafic mineral; less commonly hornblende is present and titanite, zircon and apatite are common accessory minerals. Microcline is generally interstitial to quartz and plagioclase. It commonly rims these minerals and rarely forms large equant phenocrysts. Even rarer, microcline occurs in the core of plagioclase crystals or in antiperthitic intergrowths with plagioclase. Plagioclase (An_{11-24}) generally forms euhedral lath-shaped crystals; however, oscillatory zoned squarish plagioclase is also common.

Where the Wabigoon Fault transects the Hartman Lake Stock, a number of subparallel fault splays have developed. Cataclastic to mylonitic fabrics are well developed in these deformation zones. Potassium, as microcline, fluorine (as purple fluorite) and less commonly sulphur (as pyrite) have been introduced into these zones and indicate that these deformation zones acted as structural conduits that focussed hydrothermal fluids and gases. Where these deformation zones occur along the north contact of the Hartman Lake Stock they are pyritic and may be prospective gold targets.

Granite aplite forms a distinctive intrusive phase along the east side of the stock and occurs as dikes intruding the granodiorite and supracrustal rocks along the north contact. This rock is pink, fine to medium grained equigranular, with up to 30 percent potassium feldspar as determined by staining. In thin section, microcline occurs as interstitial and equant crystals with plagioclase and quartz; plagioclase (An_{12-17}) occurs as euhedral to subhedral grains rarely displaying oscillatory zoning and quartz occurs as both interstitial and equant crystals. Green biotite commonly replaced by euhedral epidote is the main mafic mineral with titanite, and zircon as common accessory minerals.

The third phase of the Hartman Lake Stock is a white to grey, tonalitic quartz-feldspar porphyry. It intrudes the granodiorite and granite aplite forming a large mappable unit along the southeast contact of the pluton. It also occurs as white to pink dikes along the northern contact and intrudes the supracrustal rocks west of Hartman Lake. North of Hartman Lake, the porphyry appears to form a separate highly deformed intrusion with numerous metasedimentary and amphibolite inclusions.

Along the southeast side of the pluton, quartz-feldspar porphyry occurs as a foliated unit up to 400 m thick. Here rounded plagioclase and quartz phenocrysts up to 5 mm occur in a quartzofeldspathic groundmass containing up to 10 percent biotite. The porphyry passes abruptly into granodiorite and only a few porphyry dikes intrude the granodiorite near this contact.

The porphyry north of Hartman Lake displays various degrees of reaction and interaction with the country rock. Near the Hartman–MacFie Township line, foliated porphyry is texturally and mineralogically similar to the porphyry along the southeast contact. Farther west, metasedimentary inclusions that retain bedding occur and north of Hartman Lake metasedimentary inclusions with diffuse borders and network veins of porphyry are present. Here the inclusions appear to have reacted with and contaminated the porphyry. Along Highway 72 amphibolite inclusions in various stages of preservation occur and where the porphyry has partially assimilated the amphibolite the bulk composition becomes dioritic or monzodioritic. In several places along Highway 72, a distinctive intrusion breccia occurs. This breccia is characterized by deformed amphibolite and dioritic clasts in a highly deformed, porphyritic diorite to biotitic-hornblendic matrix. It appears that in a few places the quartz-feldspar porphyry has intruded and assimilated amphibolite and has then been deformed thereby brecciating itself. Where deformation is less intense, the intrusion breccias display angular to rounded amphibolite inclusions in a tonalite groundmass and occur as distinct dikes crosscutting amphibolite.

Sandybeach Lake Stock

Approximately one third of the Sandybeach Lake Stock underlies the map area with the remainder in McAree and MacFie townships to the east. Grey quartz monzonite to quartz diorite comprises the bulk of the intrusion and is medium grained, equigranular and has a strong mineral and fracture foliation. Green biotite and hornblende are the major mafic minerals with titanite and apatite as common accessory minerals. Biotite and hornblende are erratically distributed such that in one outcrop hornblende is predominant over biotite while in another outcrop biotite may be predominant over hornblende. Microcline is generally interstitial and less commonly forms rims around plagioclase. Plagioclase (An_{17-28}) occurs as laths and equant grains and only rarely displays oscillatory zonation. Mafic inclusions from 1 to 30 cm long are common and rarely form up to 2 percent of the rock.

Along the western contact of the pluton a porphyritic monzonite occurs. This rock is characterized by large (up to 1 cm) laths of antiperthitic plagioclase in a hornblende-biotite-magnetite groundmass. The rock is very distinctive with pink phenocrysts in a dark green magnetic groundmass. In thin section microcline is exsolved along plagioclase twin planes and many of the feldspars exhibit a schiller effect in hand sample. Primary biotite and hornblende form euhedral crystals and are partially overgrown by metamorphic epidote. Apatite is a common accessory mineral. A pronounced airborne magnetic high (Ontario Geological Survey 1987c) is coincident with this rock and based on the "bulls eye" nature of the aeromagnetic pattern the monzonite is spatially restricted to a small portion of the pluton along the southwest contact.

Results from the airborne geophysical surveys carried out in the entire Dryden area (Ontario Geological Survey 1987a-f) indicate the Sandybeach Lake Stock is more complex than previously interpreted (Berger 1989). The total intensity airborne magnetic pattern suggests the stock is a single entity characterized by broadly elevated magnetics (Ontario Geological Survey 1987c, 1987d). However, there are very strong electromagnetic conductors under Sandybeach Lake in areas supposedly underlain by the stock. Examination of all available outcrops of the stock shows it to be quartz monzonite to monzonite devoid of any electrically conductive material. Further, examination of recent airborne gradiometer data shows the Sandybeach Lake Stock as a series of northeast-trending magnetic highs flanked by magnetic lows and the stock no longer appears as a single entity. These data suggest that the stock may be a series of granitic sheets intruded into Minnitaki Group metasediments that are graphitic, sulphiditic and argillaceous. In the author's opinion, the strength of the airborne electromagnetic conductors precludes conductive surface material and a more plausible explanation is that the conductors are shallowly dipping as predicted by the first stage deformation known to affect this area (Chorlton 1987).

Gardnar Lake Stock

The Gardnar Lake Stock is an oval intrusion underlying the Gardnar Lake area in central Laval Township. It has intruded members of the Neepawa Group and has deformed these rocks in a narrow (100 to 200 m) steeply dipping contact strain aureole.

White to pink granodiorite is the dominant rock type and is medium grained, equigranular to slightly quartz porphyritic. The stock exhibits a weakly developed mineral and spaced fracture foliation which is approximately concentric with the contacts of the stock and is interpreted to be a primary intrusion feature. Later deformation has created small microscopic crushed zones and fractures and metamorphism has converted primary biotite to epidote.

In thin section, microcline is observed to occur principally around the rims of plagioclase crystals and perthitic textures are common. Microcline also occurs interstital to quartz and plagioclase. Plagioclase occurs as euhedral laths and squarish crystals which exhibit strong oscillatory zonation. Crystals that exhibit less strongly developed zonation were optically determined to be andesine (approximately An_{34}). Quartz occurs mainly in the groundmass although rarely porphyritic quartz phenocrysts (up to 7 mm) are present. Green biotite is the major mafic mineral and titanite and magnetite occur in trace amounts.

Pink and white granitic aplite intrude the granodiorite and the supracrustal rocks around the periphery of the stock. The aplite is fine- to very fine grained equigranular and is a late and minor phase of the stock.

The stock has a well defined and abrupt contact with the country rock. Along the western contact a few dikes and aplite stringers in the country rock pass rapidly into white granodiorite without significant stoping. Stoping is more common along the eastern contact but it is confined to a narrow zone and abruptly passes into massive granodiorite.

Crossecho Lake Stock

The Crossecho Lake Stock underlies the northeastern part of Laval Township and extends northward into the adjacent Echo, Webb and McAree townships. This stock is similar to the Gardnar Lake Stock in that it has well defined abrupt contacts and a narrow, steeply dipping contact strain aureole developed in the country rock. The main rock type is a pink granodiorite which is medium to coarse grained and quartz porphyritic to equigranular. Quartz phenocrysts are commonly large, i.e., up to 2 cm in size, rounded to doubly terminated and this feature serves to distinguish the Crossecho Lake Stock from other plutons in the map area.

In thin section, euhedral plagioclase (An_{12-28}) is the most abundant mineral and many of the crystals show poorly to well developed oscillatory zonation. This zonation is enhanced by preferential epidotization or sericitization of either the core or narrow con-

centric zones in the crystals. Quartz occurs as large porphyritic phenocrysts and as anhedral grains interstital to feldspar. Rarely apatite, hornblende and titanite are inclusions in the larger phenocrysts. Microcline occurs in a variety of habits. Most commonly microcline is interstital to plagioclase and in this habit may form large optically continuous crystals completely enclosing other crystals. Microline also commonly occurs in perthitic and antiperthitic intergrowths with plagioclase in a number of samples. Rarely microcline occurs in the core of plagioclase crystals as anhedral grains which are not necessarily aligned with the plagioclase twinning planes. Green biotite and less commonly green hornblende are the major mafic minerals and generally comprise less than 20 percent of the rock. Commonly these minerals are metamorphosed to epidote and rarely to hematite. Apatite and titanite are accessory minerals in very minor quantities.

A white equigranular, biotitic rock forms a very minor component of the Crossecho Lake Stock and in the field was mapped as tonalite. It is gradational into granodiorite and occurs in the central part of the intrusion. In thin section, the rock is composed of approximately 85 to 90 percent plagioclase (An_{28-36}) less than 5 percent quartz and approximately 5 to 10 percent biotite. This indicates leucodiorite or anorthosite would be a more appropriate name for this rock (Streckeisen 1976). The plagioclase is more calcic here than in the rest of the pluton and the scarcity of quartz suggests the leucodiorite is the earliest crystallized phase of the Crossecho Lake Stock.

Pink granitic aplite occurs as a border phase prominent along the southeast contact of the pluton and as stringers intruding the granodiorite but only rarely intruding the country rock. Careful mapping, mainly by Chorlton (1986), indicates the aplite was intruded syntectonically with the last stage of regional deformation but clearly postdates intrusion and crystallization of the main phase granodiorite.

Thin section study of tectonic fabrics shows that quartz from the central part of the pluton has undergone low strain with only subgrain development and very little undulose extinction. Feldspar crystals are relatively undeformed. Quartz from the periphery of the pluton is more highly strained and small zones of crushed and recrystallized grains are common. Feldspar crystals are commonly broken or rarely kinked. These features support the aplite data and indicate that for the most part, the Crossecho Lake Stock acted as a rigid buttress and sustained only a small amount of rotation during regional deformation (Chorlton 1986).

OTHER FELSIC INTRUSIONS

A number of felsic dikes intrude the supracrustal rocks that cannot be clearly identified as belonging to either the granitoid plutons or the felsic metavolcanics. The most common of these types of intrusion are white to pink tonalite forming dikes in the metasediments and less commonly in the mafic metavolcanics. The tonalite intrusions occur along northeast-trending foliation planes and form discontinuous dikes from 3 cm to 50 m wide and up to 250 m long. They may be the products of partial melting of the metasediments; however, field evidence is inconclusive and unclear.

Monzonite to granodiorite dikes form a swarm of intrusions southwest of Gardnar Lake. These intrusions are not obviously related to the Gardnar Lake Stock. Several appear to have assimilated the host mafic metavolcanics and their bulk composition no longer resembles the Gardnar Lake granodiorite. Further, these dikes appear to be syntectonic with the first stage deformation which predates intrusion of the Gardnar Lake Stock (*see* Structure and Metamorphism). These dikes are medium grained equigranular with mafic mineral content, generally hornblende, ranging from 10 to 50 percent. They are quartz poor containing less than 5 percent quartz to slightly quartz porphyritic containing more than 25 percent quartz.

Granitic pegmatite and aplite form a distinctive intrusive suite in the map area and are known to extend eastward into McAree Township. These rocks are subdivided into pink and white varieties. There appears to be a crude spatial and mineralogical separation of the two varieties in the field. The pink variety occurs closest to the northern contact of the Sandybeach Lake Stock and generally contains more amphibolite than metasedimentary xenoliths. The pink colouration in the pegmatite commonly intensifies around the periphery of the amphibolite xenoliths which suggests the colour is a result of hematite staining and interaction with the iron in the xenolith. Mineralogically the pink pegmatite contains quartz, sodic and potassium feldspar, biotite, muscovite, garnet and rarely tourmaline.

The white pegmatite and aplite occur gradational to the pink variety along the north contact of the Sandybeach Lake Stock, as dikes and stringers intruding the metasediments in Laval and northern Hartman townships and as a separate stock-like intrusion in western Hartman Township. This rock is mineralogically similar to the pink variety except tourmaline is more abundant and fibrolitic sillimanite is rarely present. Metasedimentary xenoliths and metatexite are more common in the white pegmatite than in the pink variety and along with the occurrence of fibrolitic sillimanite indicates the pegmatite is peraluminous; of "S"-type granitoid affinity (Chappell and White 1974) and is likely of anatectic origin. Similar white pegmatite occurs elsewhere in Ontario (Percival et al. 1985; Berger 1986) and Satterly (1943) observed similar rocks in Brownridge Township where they are associated with rare element mineralization. The white pegmatite is a potential host for economic lithium, gallium, niobium and tantalum mineralization in the map area (*see* Economic Geology).

The pink pegmatite intrudes the Sandybeach Lake Stock as dikes and stringers along the northern contact. Further xenoliths of the stock occur in both white and pink varieties and these observations indicate the pegmatite is younger than the stock.

LATE ARCHEAN

MAFIC INTRUSIONS

Lamprophyre dikes are uncommon in the map area and only one occurrence was observed. In this outcrop, a hornblende-rich rock containing numerous granitic, mafic and metasedimentary xenoliths clearly intruded the host wackes. This dike is very similar to one observed by Berger (1989) in McAree Township and may be the on-strike extension of the same dike. The lamprophyre contains 1 to 3 percent biotite in a tremolite-plagioclase groundmass. Biotite-bearing granitoid xenoliths are most abundant and small 2 to 5 mm thick reaction rims or annealed surfaces are present on some of the xenoliths. Mafic xenoliths from 1 to 8 cm long are rarely present and composed predominantly of hornblende. Wacke xenoliths are common in the lamprophyre dike in the map area but are rare in McAree Township (Berger 1989). The occurrence of granitoid and wacke xenoliths indicate the dike is among the youngest rocks in the map area.

CENOZOIC

QUATERNARY

Pleistocene and Recent

Zoltai (1961) first described the glacial history of part of northwestern Ontario including the map area. Cowan (1987) has recently examined the surficial geology and till geochemistry of the Wabigoon Lake–Gold Rock areas which includes the map area and much of this section refers to this report.

Extensive sand and gravel deposits underlie southern Laval and northern Hartman townships and thin (1 to 4 m) varved clay deposits locally overlie the granular material. Cowan (1987) has interpreted this area as glaciolacustrine deep water deposits and glaciofluvial outwash deposited during the late Wisconsinan age (11 000 to 9500 years before present (BP)). Glacial striae indicate ice generally advanced towards the southwest with striae maxima at 210 degrees plus or minus 20 degrees (Cowan 1987). Till deposits which are suitable media for overburden exploration are rare or absent in the map area.

There is commercial exploitation of the sand and gravel deposits along Highway 72 in Hartman Township. These deposits appear to be the only ones easily available for development in the map area at present as most of the remaining sand and gravel underlies the Lola Lake Provincial Nature Preserve.

Included within the Lola Lake Provincial Nature Preserve are extensive wetland (string bog) and peat deposits. These occur immediately south of Lola Lake and extend into northern Hartman Township. Preservation of these deposits was the main purpose in creating the nature preserve (Government of Ontario 1985).

A total of 35 rock samples from the map area were submitted to the Geoscience Laboratories Section, Ontario Geological Survey, for major oxide and selected trace element analyses. The main purpose of the geochemistry was to determine if the metavolcanic groups and formations recognized in the field had distinctive geochemical signatures which could be used to further distinguish amongst them. Sampling concentrated on the Neepawa Group in Laval Township with the intent of demonstrating the chemical affinities of formation A and formation B. A number of discrimination diagrams are presented to graphically illustrate geochemical trends and where appropriate data collected by L.B. Chorlton or by the author (Berger 1989) from adjacent areas are incorporated into this report.

Figure 2 shows that all metavolcanics are subalkalic which is a prerequisite criterion for using the AFM and cation plots (Irvine and Baragar 1971; Jensen 1976). Figure 2 also shows a fairly uniform silica distribution with a number of samples between 55 and 65 percent SiO_2. A bimodal distribution, as is common in many greenstone belts (Ayres et al. 1985), is not apparent from this diagram.

SOUTHERN VOLCANIC BELT

The Southern Volcanic Belt including the Thunder River Volcanics (Satterly 1943) is composed of predominantly subalkalic mafic metavolcanics (Table 2). The AFM plot (Figure 3a; Irvine and Baragar 1971) indicates the majority of flows are tholeiitic with only minor calc-alkalic members. The cation plot (Jensen 1976) (Figure 3b) shows that the metavolcanics are classified as tholeiitic basalts and calc-alkalic basalts and andesites. The data are tightly clustered which indicates limited variation in bulk composition and that the magmas are relatively undifferentiated to weakly calc-alkalic. The general lack of intermediate and felsic end members in this group hampers interpretation of differentiation trends if present. Assuming that the Southern Volcanic Belt is relatively undifferentiated is consistent with the field evidence that these rocks were rapidly deposited and buried by subsequent flows in a deep subaqueous environment.

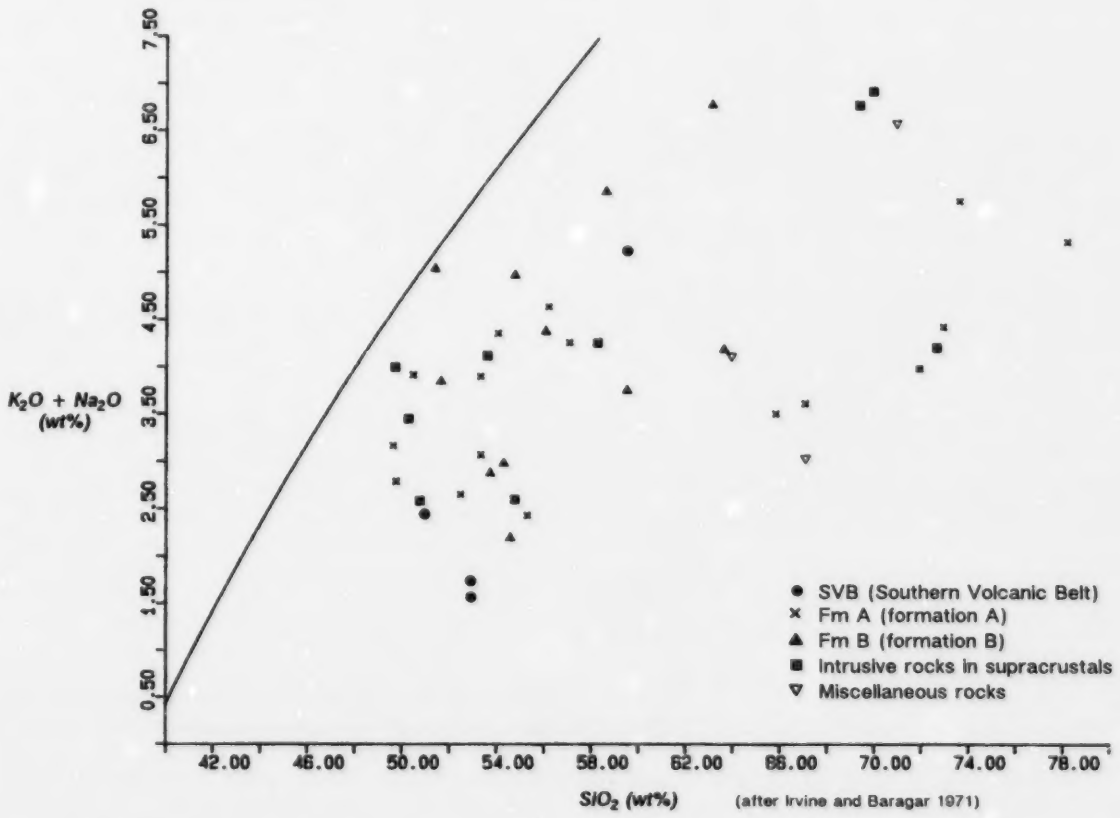


Figure 2. *SiO_2 versus $K_2O + Na_2O$.*

TABLE 2. GEOCHEMICAL DATA FOR THE SOUTHERN VOLCANIC BELT.

Major Oxide Listing (weight percent)

	0003*	0017	0098	0100
SiO_2	55.20	51.70	51.20	48.50
TiO_2	0.81	0.60	0.67	1.96
Al_2O_3	15.40	14.30	15.00	13.20
Fe_2O_3	1.45	1.97	1.75	4.00
FeO	5.99	8.85	7.79	11.70
MnO	0.18	0.18	0.30	0.24
MgO	2.86	7.74	7.17	4.82
CaO	5.87	10.70	11.30	8.34
Na_2O	3.81	1.40	1.33	2.15
K_2O	1.02	0.27	0.17	0.20
P_2O_5	0.14	0.03	0.04	0.18
CO_2	3.54	0.13	0.27	0.40
S	0.01	0.01	0.02	0.09
H_2O^+	3.12	1.67	1.92	3.49
H_2O^-	00.00	00.00	00.00	00.00
LOI	5.80	1.20	1.50	2.80
TOTAL	99.40	99.50	98.90	99.30
S.G.	2.74	3.07	3.01	3.00

Trace Element Listing

	Method	0003		0017		0098		0100	
As	AA	10		-1		-1		2	
Au	AA	-2	B	-2	B	-2	B	-2	B
Ba	AA	325		89		140		78	
Co	AA	22		43		42		45	
Cr	AA	60		387		325		51	
Cu	AA	44		72		152		156	
Ni	AA	57		76		60		27	
Pb	AA	25		28		15		12	
Zn	AA	93		93		81		149	
Be	ICP/OES	2		1		1		2	
Co	ICP/OES	17		38		35		39	
Cu	ICP/OES	42		69		146		157	
Mo	ICP/OES	-10		-10		-10		-10	
Ni	ICP/OES	53		76		59		29	
Sc	ICP/OES	17		43		43		39	
Sr	ICP/OES	184		75		134		223	
V	ICP/OES	138		255		255		354	
W	ICP/OES	-50		-50		-50		-50	
Y	ICP/OES	15		14		17		31	
Zn	ICP/OES	95		87		79		137	
Nb	XRF	-5		-5		-5		5	
Rb	XRF	32		6		-5		8	
Sr	XRF	193		96		149		239	
Y	XRF	18		17		20		41	
Zr	XRF	139		70		77		161	
Th	XRF	-10		-10		-10		10	
F	COLORIM	330		80		340		430	

87BRB-0003 - Mafic tuff from the southeast corner of Hartman Township.
87BRB-0017 - Massive amphibolite from central Hartman Township.
87BRB-0098 - Massive amphibolite from southwest corner of Hartman Township, along hydro line south of Nugget Creek.
87BRB-0100 - Massive basalt from large outcrop in southeast corner of Hartman Township.
**All sample numbers are abbreviated from the standard OGS sample number, e.g., 87BRB-0003.*

The plot of TiO_2 versus Cr (Figure 4) indicates that all members of the Southern Volcanic Belt contain less than 2 weight percent titanium dioxide and most contain less than 1.6 percent. There is considerable overlap of this data with formation B of the Neepawa Group; however, the pyroxene-hornblende-phyric morphology and predominance of pyroclastic deposits serves to distinguish these rocks from the Southern Volcanic Belt.

To a lesser extent members of formation A of the Neepawa Group overlap with the Southern Volcanic Belt; however, for the most part these rocks contain higher TiO_2 and have a narrow range of chromium.

Trowell et al. (1983) have geochemically examined members of the Southern Volcanic Belt east of Sioux Lookout and obtained similar patterns to those presented here. This indicates the Southern Volcanic Belt is regionally similar in geochemistry as well as in lithology from east of Sioux Lookout to the map area. This is interpreted as the result of widespread rapid accumulation of mafic lava on a seafloor plain. A mafic shield volcano as proposed by Easton and Johns (1986) is the probable source for the lavas.

NEEPAWA GROUP

Field mapping indicates the Neepawa Group is divisible into two morphologically distinct formations in the map area. Formation A is composed of mafic and felsic flows with subordinate fragmental deposits and is intruded by subvolcanic metagabbro and metadiorite dikes and sills. Formation B is composed of mafic and intermediate pyroxene-hornblende-phyric pyroclastic deposits with subordinate flows. The contact between the two formations is transitional, commonly with intercalation of units; however, it can be abrupt where structural juxtaposition and complications occur. Rock samples were collected and analyzed from each formation in order to detect differences, if any, in geochemistry.

FORMATION A

Formation A is subalkalic (Figure 2) and tholeiitic in composition. Figure 5a, the AFM diagram, indicates most of the analyzed samples are tholeiitic and that there is a well defined tholeiitic trend, with pronounced iron enrichment. Figure 5b shows the cation plot for formation A and indicates that there is almost complete tholeiitic differentiation from magnesium-rich tholeiitic basalts to tholeiitic and calc-alkalic rhyolites. Intermediate members such as andesite and dacite were not separated in the field and were mapped either as basalt or rhyolite. Further, variolitic and spherulitic rocks have bulk compositions that plot as tholeiitic andesite or dacite although these rocks are composed of separate felsic and mafic components. Felsic members are white to black rhyolite flows with or without spherulites and rhyolitic segregations within basaltic flows or narrow, discontinuous rhyolitic bands within variolitic-spherulitic flows. Problems identifying phaneritic basalt from gabbro occurred in the field, however, as shown below this was not a major problem geochemically.

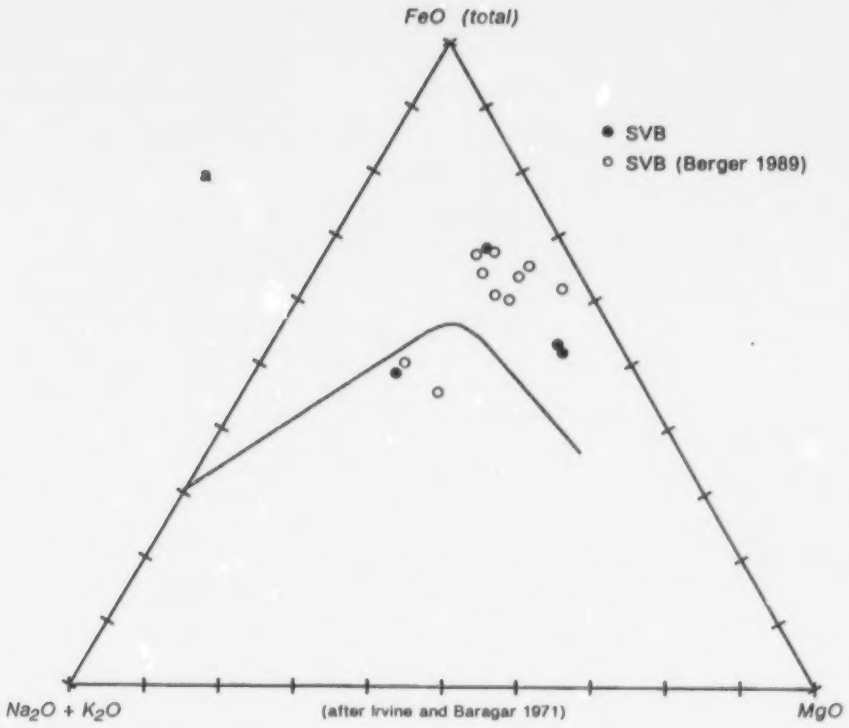


Figure 3a. *AFM plot for the Southern Volcanic Belt.*

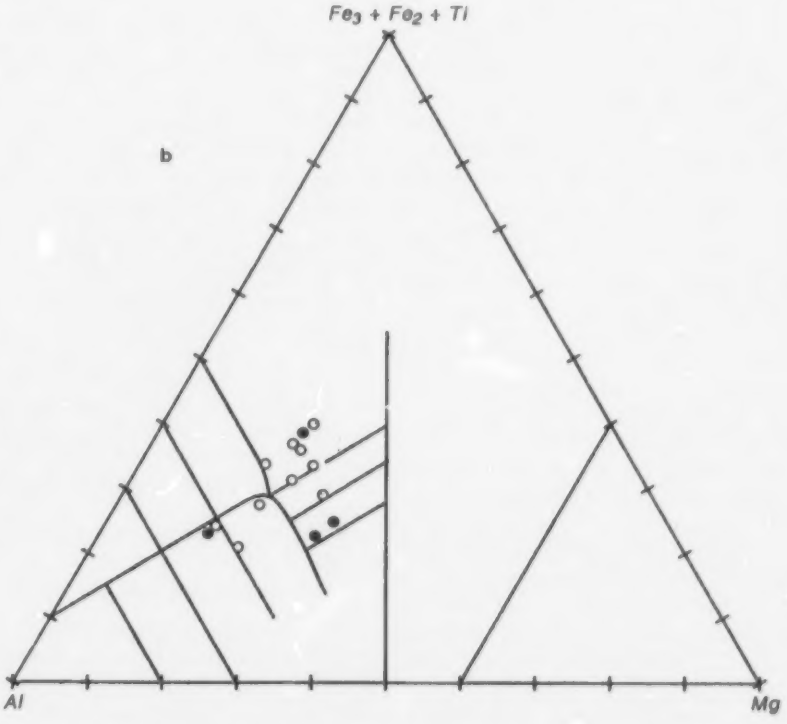


Figure 3b. *Cation plot for the Southern Volcanic Belt.*

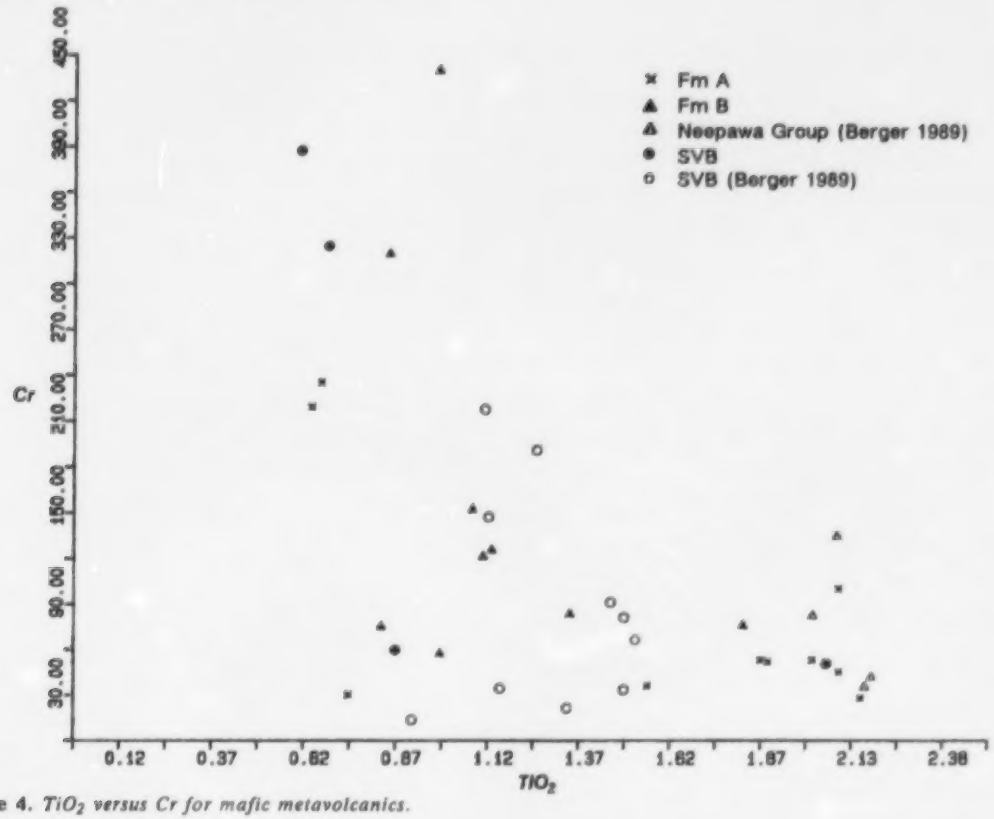


Figure 4. *TiO_2 versus Cr for mafic metavolcanics.*

Trace element data for formation A show interesting trends and are presented in Table 3. Figure 6, zirconium versus yttrium and Figure 7, vanadium versus scandium, were selected to illustrate two important trends exhibited by trace elements in formation A. Firstly, there is an approximately linear trend in the basaltic and the rhyolitic samples. However, the rhyolite rocks still lie on the same linear trend as the more mafic rocks. Two samples deviate from this trend and both are at or near the contact with formation B rocks. The deviation is attributed to intermixing or contamination by formation B geochemical processes. Figure 7 shows a pronounced gap between mafic-intermediate and felsic members bridged by variolitic-spherulitic units and the same samples transitional to formation B. The data also defines an approximately linear trend similar to Figure 6.

The geochemical trends outlined above for formation A can be related directly to field observations. The tholeiitic differentiation trend (Figure 5) is evident in the field in various forms. Iron-enriched basalts are commonly magnetic and magnetite pods and disseminations are common in some of the most enriched rocks. Rhyolitic rocks occur as narrow units, small pods in basalts and as groundmass to varioles-spherulites. In the latter two occurrences, the rhyolite is interpreted as the product of immiscible liquid splitting. Intermediate members of formation A occur as variolitic-spherulitic flows with separate felsic and mafic components which when analyzed in bulk return andesitic to dacitic compositions. Intermediate units are also represented by some flows exhibiting well developed colour banding (grey and buff) which presumably reflect different geochemical compositions. These rocks are interpreted to represent more homogenized versions of the spherulitic rocks and given sufficient time would have developed separate felsic and mafic components.

Thurston and Fryer (1983) indicated that ideal crystal fractionation should produce linear relationships between incompatible elements, notably yttrium and zirconium. The linear trend defined by Figure 6 and supported by Figure 7 suggests crystal fractionation was involved during differentiation of formation A. The trace element gaps on Figures 6 and 7 support liquid immiscibility in that partitioning of elements proceeds uniformly until differentiation produces an enriched or depleted felsic liquid (depending on the elements involved) which separates from the "evolving" magma. Whether or not this liquid forms massive flows, spherulites or flow banded intermediate units depends upon how quickly the liquid solidified.

The author envisages formation A as developing from a single magma that underwent tholeiitic differentiation. As differentiation proceeded a felsic liquid formed and began to immiscibly split from the magma. Before complete separation occurred the magma erupted and the rocks now record the various stages of separation and mixing of the two liquids.

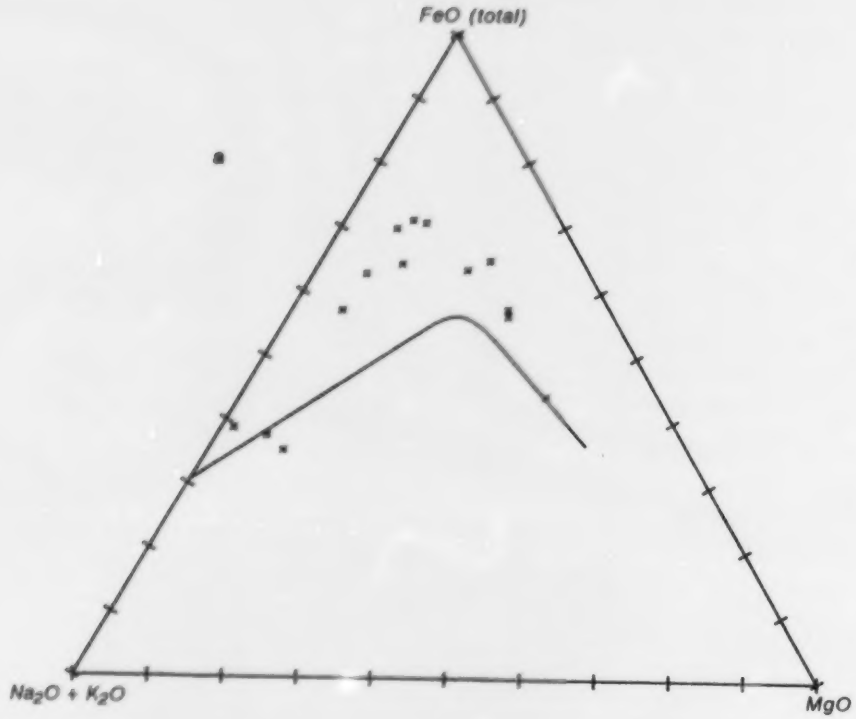


Figure 5a. *AFM plot for formation A, Neepawa Group.*

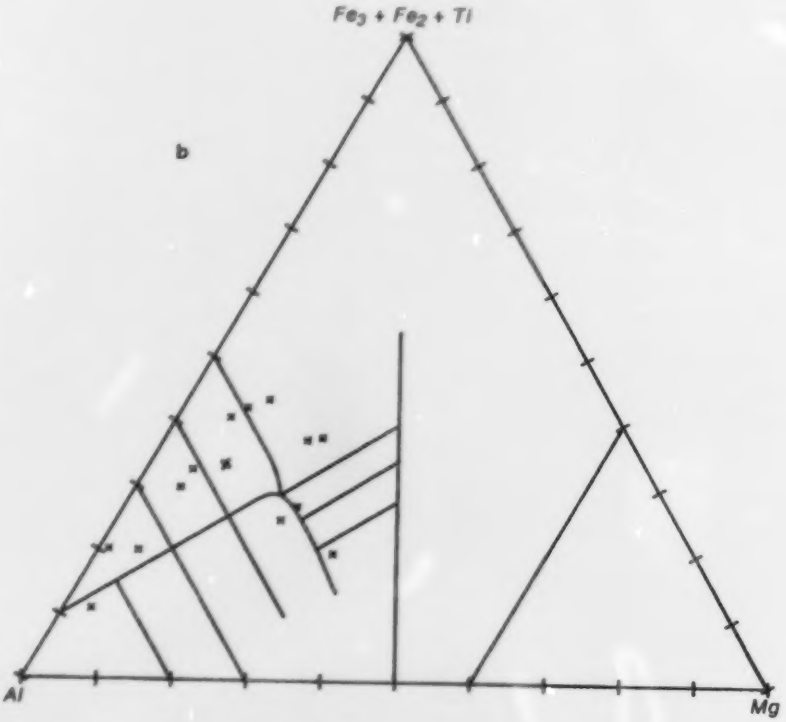


Figure 5b. *Cation plot for formation A, Neepawa Group.*

TABLE 3. GEOCHEMICAL DATA FOR FORMATION A, NEEPAWA GROUP.

Major Oxide Listing (weight percent)

	0091*	0228	0229	0230	0234	0267
SiO_2	71.00	48.40	55.40	54.20	72.40	65.10
TiO_2	0.72	2.04	1.96	1.81	0.47	1.22
Al_2O_3	11.60	13.90	13.70	14.00	11.20	18.50
Fe_2O_3	1.03	3.30	3.50	3.90	3.52	0.66
FeO	2.80	13.00	11.60	10.20	3.73	1.66
MnO	0.10	0.25	0.21	0.21	0.11	0.03
MgO	0.66	5.57	1.89	1.49	0.82	0.64
CaO	2.78	7.73	4.44	5.92	2.52	5.50
Na_2O	5.15	2.94	1.92	3.49	4.30	3.16
K_2O	0.38	0.14	2.20	0.97	0.07	0.33
P_2O_5	0.17	0.22	0.23	0.24	0.05	0.24
CO_2	2.03	0.12	0.22	1.38	0.12	0.26
S	0.05	0.09	0.08	0.09	0.03	0.04
H_2O^+	0.56	1.98	1.38	1.10	0.67	1.00
H_2O^-	00.00	00.00	00.00	00.00	00.00	0.05
LOI	2.00	0.70	0.30	1.10	0.30	0.90
TOTAL	99.00	99.70	98.70	99.00	100.00	98.40
S.G.	2.70	3.06	2.94	2.96	2.77	2.72

Trace Element Listing

	Method	0091	0228	0229	0230	0234	0267
As	AA	-1	-1	-1	-1	-1	2
Au	AA	-2 B	-2 B	3 B	-2 B	-2 B	2 B
Ba	AA	75	75	220	128	35	200
Co	AA	6	44	37	30	5	18
Cr	AA	30	100	53	53	20	149
Cu	AA	12	115	51	50	16	199
Ni	AA	10	41	23	22	-5	29
Pb	AA	35	17	18	17	-10	29
Zn	AA	34	127	142	127	85	33
Be	ICP/OES	2	2	2	2	2	2
Co	ICP/OES	4	38	34	26	4	15
Cu	ICP/OES	8	120	53	53	14	222
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Ni	ICP/OES	11	46	29	25	4	30
Sc	ICP/OES	12	42	41	39	9	21
Sr	ICP/OES	98	189	128	114	195	663
V	ICP/OES	21	352	328	322	35	184
W	ICP/OES	-50	-50	-50	-50	-50	-50
Y	ICP/OES	43	37	36	43	81	12
Zr	ICP/OES	42	119	138	124	80	45
Nb	XRF	22	6	-5	6	17	-5
Rb	XRF	-5	-5	58	37	-5	7
Sr	XRF	114	211	143	130	202	713
Y	XRF	109	46	40	54	115	19
Zr	XRF	440	147	141	175	419	196
Th	XRF	-10	-10	-10	-10	-10	-10
F	COLORIM	280	470	550	520	210	380

Major Oxide Listing (weight percent)

	0278	0279	0281	0284	0286	0294
SiO_2	70.20	50.20	48.60	52.50	51.20	76.50
TiO_2	0.62	0.61	0.35	2.09	0.63	0.57
Al_2O_3	11.50	14.00	14.60	13.60	14.80	10.70
Fe_2O_3	2.52	1.21	1.03	1.90	2.88	0.63
FeO	5.79	7.59	7.12	14.60	8.12	2.80
MnO	0.12	0.17	0.15	0.33	0.20	0.07
MgO	0.91	4.55	7.48	2.55	5.39	0.14
CaO	1.85	10.20	8.99	5.05	11.70	1.05
Na_2O	3.53	1.69	2.22	3.80	2.38	4.95
K_2O	0.34	0.51	0.57	0.42	0.20	0.24
P_2O_5	0.16	0.03	0.01	0.27	0.03	0.13
CO_2	0.49	5.77	4.41	0.79	0.64	0.76
S	0.01	0.40	0.11	0.29	0.02	0.02
H_2O^+	1.27	3.25	3.39	1.25	1.65	0.72
H_2O^-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	1.00	7.70	6.80	0.30	1.20	0.80
TOTAL	99.30	100.20	99.00	99.40	99.80	99.30
S.G.	2.77	2.80	2.83	3.01	3.04	2.68

TABLE 3. CONTINUED.

Trace Element Listing

	Method	0278	0279	0281	0284	0286	0294
As	AA	-1	4	-1	-1	2.50	-1
Au	AA	-2 B	2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	55	215	495	63	95	80
Co	AA	-5	34	37	23	45	-5
Cr	AA	15	235	770	28	219	14
Cu	AA	14	159	35	87	84	7
Ni	AA	-5	50	91	12	78	-5
Pb	AA	31	27	-10	21	20	26
Zn	AA	63	111	76	141	100	51
Be	ICP/OES	2	2	1	3	1	2
Co	ICP/OES	4	31	34	20	40	-1
Cu	ICP/OES	8	156	32	95	81	5
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Ni	ICP/OES	5	50	87	18	75	2
Sc	ICP/OES	13	45	39	44	48	7
Sr	ICP/OES	43	93	164	62	40	58
V	ICP/OES	31	250	176	374	252	6
W	ICP/OES	-50	-50	-50	-50	-50	-50
Y	ICP/OES	61	18	12	51	24	39
Zr	ICP/OES	58	109	74	131	98	57
Nb	XRF	23	-5	-5	10	-5	24
Rb	XRF	-5	13	11	13	-5	-5
Sr	XRF	64	107	173	84	61	81
Y	XRF	137	22	14	68	28	120
Zr	XRF	496	84	69	199	68	485
Th	XRF	-10	-10	-10	11	-10	12
F	COLORIM	430	470	300	450	270	330

Major Oxide Listing (weight percent)

	0297	86LBC-0119	86LBC-0133	86LBC-0179
SiO_2	50.30	46.80	45.80	63.40
TiO_2	1.79	1.94	1.44	0.89
Al_2O_3	13.30	14.40	16.70	11.50
Fe_2O_3	3.30	6.01	1.80	2.90
FeO	11.40	8.18	10.90	6.20
MnO	0.25	0.29	0.21	0.21
MgO	4.61	2.12	3.34	1.53
CaO	5.48	9.10	9.03	6.11
Na_2O	3.53	3.60	2.11	3.21
K_2O	0.14	0.02	0.45	0.15
P_2O_5	0.22	0.22	0.23	0.18
CO_2	1.54	5.13	4.80	1.82
S	0.22	0.04	0.01	0.06
H_2O^+	2.94	1.87	3.38	0.73
H_2O^-	0.08	0.07	0.13	00.00
LOI	2.80	6.00	6.90	1.70
TOTAL	99.10	99.80	100.30	98.90
S.G.	2.92	2.83	2.83	2.87

Trace Element Listing

	Method	0297	86LBC-0119	86LBC-0133	86LBC-0179
Ag	AA		-2	-2	-2
As	AA	-1	3.50	1	19
Au	AA	-2 B			
Ba	AA	50	69	99	68
Co	AA	38	35	25	8
Cr	AA	52	45	36	-10
Cu	AA	83	43	40	25
Ni	AA	27	26	24	-5
Pb	AA	-10	-10	-10	-10
Zn	AA	155	160	134	86
Be	ICP/OES	2	-1	-1	2
Co	ICP/OES	32	33	22	7
Cu	ICP/OES	78	33	32	30
Mo	ICP/OES	-10	-10	-10	-10

TABLE 3. CONTINUED.

Trace Element Listing

	Method	0297	86LBC-0119	86LBC-0133	86LBC-0179
Ni	ICP/OES	29	24	22	-1
Sc	ICP/OES	38	34	26	14
Sr	ICP/OES	74	61	221	152
V	ICP/OES	315	285	170	27
W	ICP/OES	-50			
Y	ICP/OES	47	38	26	101
Zr	ICP/OES	138	130	105	70
Nb	XRF	8			
Rb	XRF	-5			
Sr	XRF	92			
Y	XRF	63			
Zr	XRF	192			
Th	XRF	-10			
Pr	ICP-MS		3.70		10
Sm	ICP-MS		4.90		13
Eu	ICP-MS		1.50		3.10
Gd	ICP-MS		5.90		16
Tb	ICP-MS		1.10		2.70
Dy	ICP-MS		7.40		18
Ho	ICP-MS		1.60		4.10
Er	ICP-MS		4.90		12
Tm	ICP-MS		690 B		1.70
Yb	ICP-MS		4.50		11
Lu	ICP-MS		630 B		1.60
F	COLORIM	430			
Au	AA		-2 B	-2 B	9 B
Pt	AA		-1 B	-1 B	-1 B
Pd	AA		-1 B	-1 B	-1 B
Ce	ICP-MS		23		66
La	ICP-MS		9.10		27
Nd	ICP-MS		17		45
Y	ICP-MS		41		105

87BRB-0091 - Black, spherulitic rhyolitic flow west of Diamond Lake.

87BRB-0228 - Massive phaneritic basaltic flow to gabbroic sill; on bush road east of Diamond Lake.

87BRB-0229 - Flow banded andesite/dacite; possibly potassic altered; on bush road east of Diamond Lake.

87BRB-0230 - Flow banded andesite; unaltered; on bush road east of Diamond Lake and east of sample 229.

87BRB-0234 - Flow banded to autobrecciated rhyolite; on islands in Rafter Lake.

87BRB-0267 - Plagioclase-phyric to cryptocrystalline massive flow west of Gardnar Lake, near contact with formation B.

87BRB-0278 - From Hollinger Mines Limited diamond-drill hole LB1-1-78, 345 feet; andesite/dacite flow, possible equivalent to altered gabbro.

87BRB-0279 - From Hollinger Mines Limited diamond-drill hole LB1-3-78, 260 feet; mafic tuff.

87BRB-0281 - From Hollinger Mines Limited diamond-drill hole LB1-5-78, 185 feet; phaneritic mafic flow or gabbroic intrusion.

87BRB-0284 - From Hollinger Mines Limited diamond-drill hole LB1-4-78, 475 feet; massive mafic/intermediate flow.

87BRB-0286 - Core of pillowed basalt from flow west of Beartrack Lake.

87BRB-0294 - Massive black rhyolite flow near the contact with formation A and the Minnitaki Group, east of Troutfly Lake.

87BRB-0297 - Massive basalt from footwall side of Mistango Main showing southwest side of Troutfly Lake.

86LBC-0119 - Plagioclase-phyric, scoriaceous flow from Echo Township south of Goldlund Mine.

86LBC-0133 - Plagioclase-phyric flow from Echo Township; Goldlund Mine area.

86LBC-0179 - Spherulitic intermediate flow from Echo Township, west of Goldlund Mine.

**All sample numbers are abbreviated from the standard OGS sample number, e.g., 87BRB-0091, unless otherwise stated.*

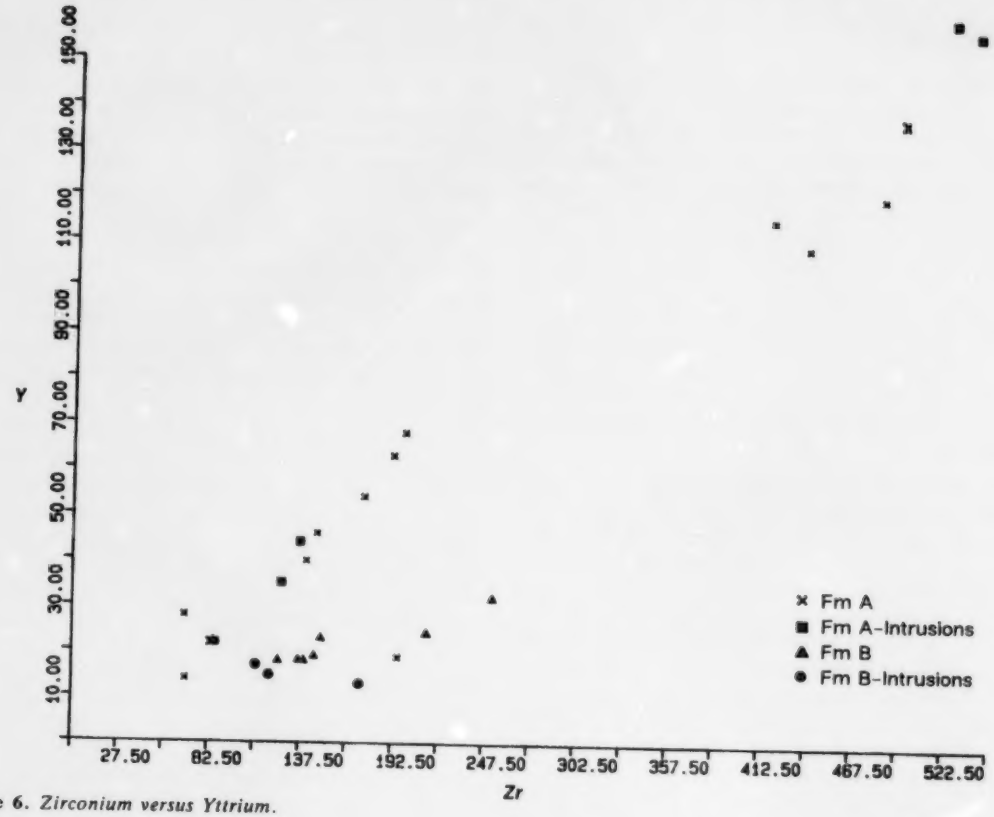


Figure 6. *Zirconium versus Yttrium.*

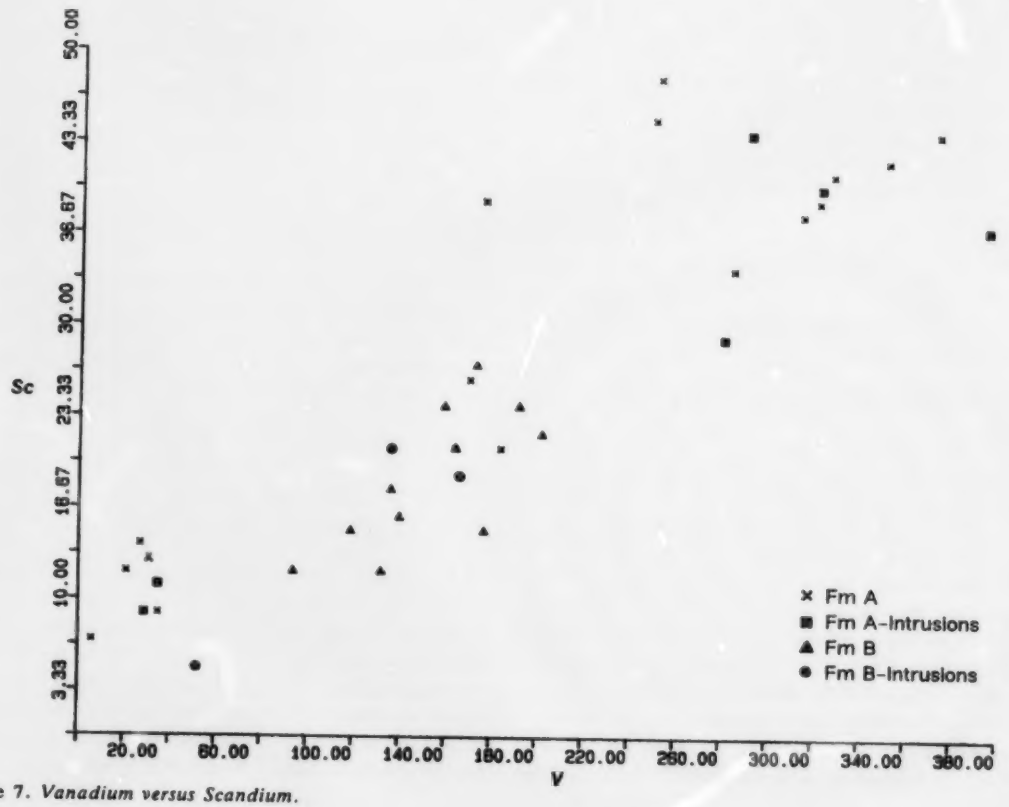


Figure 7. *Vanadium versus Scandium.*

FORMATION B

Formation B is subalkalic (Figure 2) and predominantly calc-alkalic in composition. A calc-alkalic trend is indicated on Figure 8a and Figure 8b shows most of the data clusters towards the mafic end with tholeiitic and calc-alkalic basalts dominant. Some samples contain very high alumina (approximately 19 weight percent) with respect to silica (52 to 57 weight percent) and on Figure 8b these samples plot as dacites. In the field these rocks contain abundant feldspar with trachytic textures and were mapped as andesites. In view of the low silica content the author prefers to regard these rocks as andesites. Based on the major oxide data alone there is enough evidence to indicate formation B is geochemically distinct from formation A.

Trace element data for formation B are also distinctly different than formation A and are presented in Figures 6 and 7 and Table 4. Figure 6 shows lower overall yttrium in formation B rocks and Figure 7 shows that formation B contains lower scandium and vanadium than formation A basalts and andesites. Further, formation B rocks are tightly clustered and clearly divisible from formation A rocks. Formation B rocks also contain higher barium and strontium than formation A basalts and andesites (Table 4). Formation B is, therefore, geochemically distinct from formation A and recognition of the pyroxene-hornblende-phyric morphology is sufficient evidence to infer a calc-alkalic affinity in the map area. Elsewhere, however, this same morphology represents different geochemistry. In the southern Lake of the Woods area, pyroxene-phyric and trachytic textured flows are alkalic and represent an absarokite-shosonite suite (Morrice and MacMaster 1987). Conversely similar flows in the central Lake of the Woods area are calc-alkalic and similar to the rocks in the map area (J. Ayer, Ontario Geological Survey, personal communication, 1987). A further complication in the map area is the intercalation of formation A with formation B. This has had the effect of creating mixed geochemical patterns in these transition zones and emphasizes the importance of restricting sampling to areas well within each formation.

MAFIC INTRUSIONS AND RELATED ROCKS

Gabbroic, dioritic, and tonalitic intrusions are common in all supracrustal rocks in the map area but are volumetrically and economically significant only in the Neepawa Group. Accordingly this section is directed towards describing the geochemical patterns of nongranitoid intrusions within the Neepawa Group. Specifically samples of gabbro and altered gabbro (unit 5f, Map 2534, back pocket) which intrude formation A and a gabbroic to quartz-dioritic pluton on Beartrack Lake were analyzed.

Figures 9a and 9b show that gabbros and altered gabbros from formation A are tholeiitic and that the Beartrack Lake intrusion is calc-alkalic (Table 5). Comparison of Figures 9a and 9b with Figures 5a, 5b, 8a, and 8b shows that formation A mafic intrusions are chemically similar to formation A metavolcanics, and the Beartrack Lake pluton is chemically similar to formation B metavolcanics. Similarly, Figures 6 and 7 show that trace element data for each intrusive suite closely correspond to their host metavolcanic suites. The geochemical trends outlined above support field data that intrusions in both Neepawa formations are subvolcanic and part of the supracrustal stratigraphy. Further, field data indicates mafic intrusions in both formations locally contributed magma to the metavolcanics and geochemistry also supports this interpretation.

Most interesting is the relationship between the altered gabbro and gabbro intrusions in formation A. In the field the altered gabbro is gradational into and at one place intrusive into the gabbro (Chorlton 1987) and this close spatial relationship was interpreted as indicating a genetic association. The strong chemical affinity of the altered gabbro to formation A felsic metavolcanics combined with the strong chemical affinity of the gabbro to formation A mafic metavolcanics (Figures 5a, 5b, 6, 7, 9a and 9b) implies the altered gabbro and gabbro represent two components of a differentiated magma and are the subvolcanic equivalent of the formation A basalts and rhyolites. Further, the predominance of myrmeketic textures in the altered gabbro indicates it was exsolved from the magma and possibly represents an immiscible liquid.

RARE EARTH ELEMENT DATA (REE)

Selected samples from the Neepawa Group were analyzed for their Rare Earth Element (REE) abundances and plotted on chondrite normalized graphs (Figures 10 and 11)(Table 6). Although the samples are from McAree and Echo townships northeast of the map area, they are representative of formation A and formation B lithologies.

Figure 10 shows the REE patterns for formation A. Basaltic flows are characterized by relatively flat REE patterns with minor negative europium (Eu) anomalies and a small but noticeable lutetium (Lu) depletion. For the most part these patterns are typical of tholeiites (Henderson 1984). The more felsic rocks and variolitic-spherulitic rocks are enriched in total rare earth abundances, show a more pronounced negative Eu anomaly and a noticeable Lu depletion. However, the essentially flat tholeiitic pattern is retained and this is consistent with derivation of the felsic rocks by differentiation within a geochemically closed system. That differentiation as indicated by Figure 10 is consistent with the major and trace element data and the field data for formation A.

Figure 11 shows the REE patterns for two samples from formation B. The patterns are very different than for formation A and this emphasizes the chemical differences between the two formations. Forma-

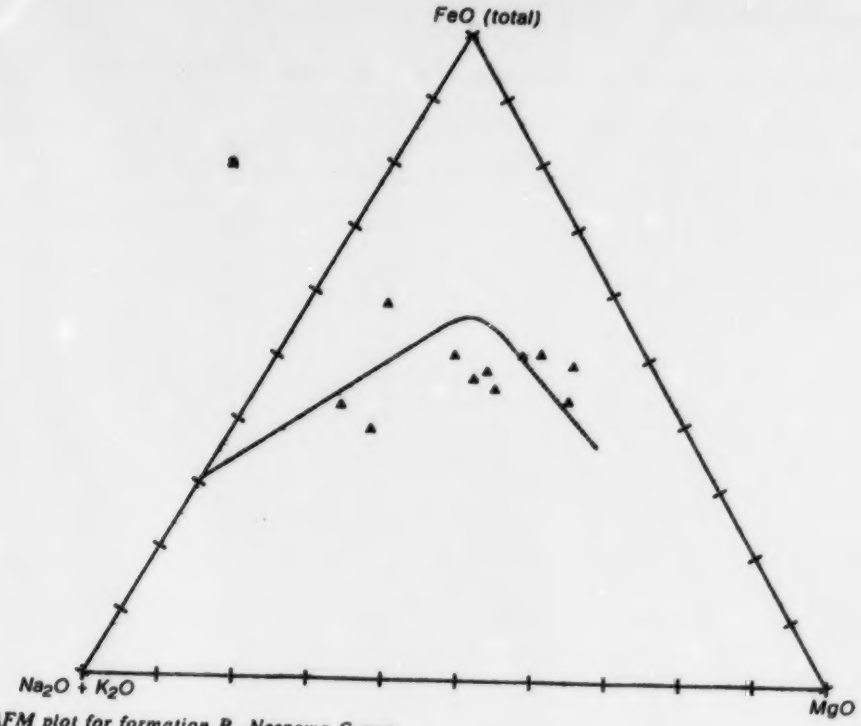


Figure 8a. *AFM plot for formation B, Neepawa Group.*

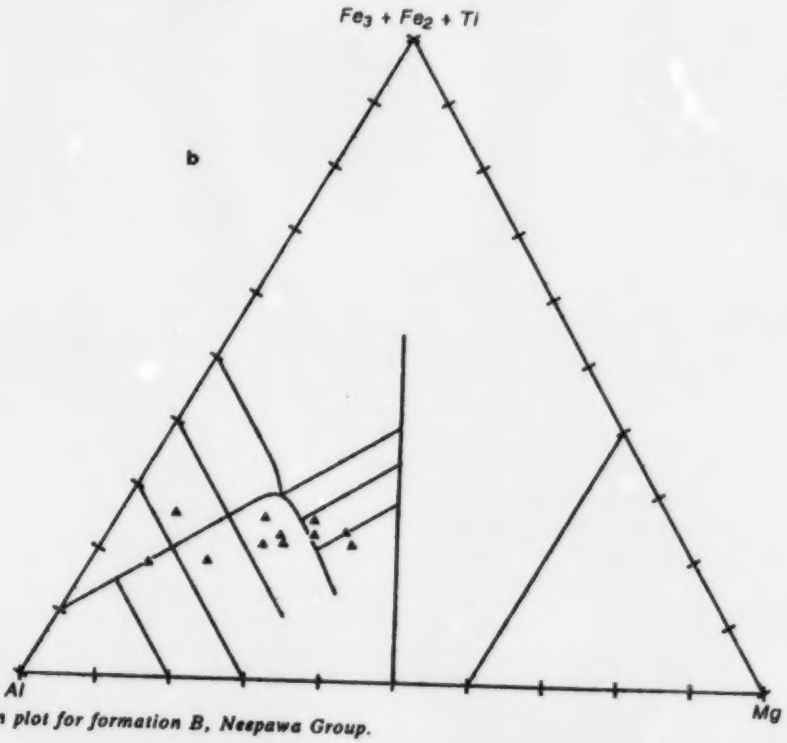


Figure 8b. *Cation plot for formation B, Neepawa Group.*

tion B rocks are characterized by light rare earth enrichment (La/Yb 13 to 16) although total abundances of REE are very different for the two samples. Sample 86BRB-0609 has a similar pattern and total REE abundance to morphologically similar rocks with alkalic chemistry in the Lake of the Woods area that have been equated with modern island arc volcanism (Morrice and MacMaster 1987). Further sampling and regional correlation is required to verify these trends in both areas; however, there appears to be sufficient data at this time to seriously consider an island arc-like evolution for these volcanic sequences.

TABLE 4. GEOCHEMICAL DATA FOR FORMATION B, NEEPAWA GROUP.

Major Oxide Listing (weight percent)

	0029*	0030	0224	0269	0350	0534
SiO_2	52.70	57.70	52.90	52.80	57.10	52.10
TiO_2	1.76	0.81	0.94	0.83	1.32	0.95
Al_2O_3	19.40	16.20	16.40	14.40	19.50	14.70
Fe_2O_3	1.33	2.09	1.95	3.20	0.95	2.20
FeO	7.65	5.72	6.32	6.66	4.53	6.66
MnO	0.18	0.10	0.12	0.16	0.11	0.13
MgO	1.63	4.65	5.58	7.83	1.60	8.40
CaO	6.34	5.90	5.79	8.57	6.29	7.77
Na_2O	3.60	3.09	3.26	1.44	4.40	2.32
K_2O	1.17	0.53	0.86	0.68	1.29	0.53
P_2O_5	0.48	0.14	0.20	0.17	0.31	0.19
CO_2	1.26	0.12	2.13	0.38	1.00	0.22
S	0.01	0.01	0.01	0.01	0.01	0.01
H_2O^+	1.81	2.44	3.46	1.63	1.27	3.06
H_2O^-	0.05	00.00	0.09	00.00	00.00	00.00
LOI	2.00	1.90	4.80	2.00	1.60	2.40
TOTAL	99.40	99.50	100.00	98.80	99.70	99.20
S.G.	2.79	2.83	2.78	2.89	2.75	2.87

Trace Element Listing

	Method	0029	0030	0224	0269	0350	0534
As	AA	-1	-1	-1	-1	-1	-1
Au	AA	-2 B	-2 B	18 B	-2 B	-2 B	-2 B
Ba	AA	325	175	236	190	460	136
Co	AA	25	27	27	42	17	39
Cr	AA	76	75	57	319	83	440
Cu	AA	77	61	63	40	94	53
Ni	AA	78	76	75	189	37	250
Pb	AA	42	43	19	23	-10	-10
Zn	AA	131	79	101	109	88	102
Be	ICP/OES	3	2	2	2	2	2
Co	ICP/OES	19	24	24	36	15	37
Cu	ICP/OES	78	56	61	37	90	52
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Ni	ICP/OES	80	74	73	176	50	241
Sc	ICP/OES	15	18	16	27	12	24
Sr	ICP/OES	542	392	315	429	512	379
V	ICP/OES	177	136	140	173	132	159
W	ICP/OES	-50	-50	-50	-50	-50	-50
Y	ICP/OES	22	12	16	17	16	15
Zn	ICP/OES	129	82	98	105	78	103
Nb	XRF	11	-5	-5	-5	6	-5
Rb	XRF	35	8	18	17	39	16
Sr	XRF	618	390	319	431	604	374
Y	XRF	32	18	23	19	24	18
Zr	XRF	253	137	150	146	213	140
Th	XRF	17	-10	-10	-10	-10	10
F	COLORIM	570	360	230	460	480	320

Major Oxide Listing (weight percent)

	86BRB-0609	86LBC-0060	86LBC-0109	86LBC-0117	87BRB-0235
SiO_2	49.00	49.30	50.50	60.90	61.10
TiO_2	1.08	1.07	1.02	0.59	0.71
Al_2O_3	15.70	15.90	15.90	16.00	13.90
Fe_2O_3	2.91	3.16	3.21	2.26	2.03
FeO	7.55	6.52	6.20	3.50	5.79
MnO	0.14	0.18	0.14	0.12	0.11
MgO	6.56	4.43	6.66	2.85	4.70
CaO	8.05	10.30	7.51	3.64	3.42
Na_2O	3.27	4.69	2.26	5.75	3.20
K_2O	0.37	0.14	0.44	0.77	0.80
P_2O_5	0.27	0.20	0.18	0.10	0.21
CO_2	1.29	3.15	0.55	1.68	0.26
S	0.01	0.01	0.01	0.01	0.22
H_2O^+	2.88	1.28	3.28	1.62	2.51
H_2O^-	0.11	0.05	0.11	0.07	0.09
LOI	3.20	3.30	3.10	2.80	2.20
TOTAL	99.20	100.30	98.00	99.80	99.10
S.G.	2.82	2.86	2.87	2.67	2.80

TABLE 4. CONTINUED.

Trace Element Listing

	Method	86BRB-0609	86LBC-0060	86LBC-0109	86LBC-0117	87BRB-0235
Ag	AA	-2	-2	-2	-2	
As	AA	3.50	3	1.50	5.50	-1
Au	AA					9 B
Ba	AA	155	78	132	301	140
Co	AA	37	29	35	14	26
Cr	AA	125	121	152	30	131
Cu	AA	62	58	57	26	79
Ni	AA	129	100	141	20	70
Pb	AA	-10	-10	-10	18	18
Zn	AA	109	109	108	48	100
Be	ICP/OES	-1	-1	-1	-1	1
Co	ICP/OES	36	28	33	13	23
Cu	ICP/OES	56	49	47	21	76
Mo	ICP/OES	-10	-10	-10	-10	-10
Ni	ICP/OES	130	97	140	20	70
Sc	ICP/OES	22	24	21	12	15
Sr	ICP/OES	557	317	393	84	229
V	ICP/OES	202	192	164	94	118
W	ICP/OES					-50
Y	ICP/OES	17	16	15	12	14
Zn	ICP/OES	85	86	82	34	100
Nb	XRF					-5
Rb	XRF					23
Sr	XRF					224
Y	XRF					18
Zr	XRF					125
Th	XRF					-10
Pr	ICP-MS	7.50				
Sm	ICP-MS	5.60				
Eu	ICP-MS	1.70				
Gd	ICP-MS	4.50				
Tb	ICP-MS	610 B				
Dy	ICP-MS	3.60				
Ho	ICP-MS	710 B				
Er	ICP-MS	2				
Tm	ICP-MS	260 B				
Yb	ICP-MS	1.60				
Lu	ICP-MS	220 B				
F	COLORIM					
Au	AA	-2 B				
Pt	AA	-1 B				
Pd	AA	-1 B				
Ce	ICP-MS	52				
La	ICP-MS	21				
Nd	ICP-MS	29				
Y	ICP-MS	18				

87BRB-0029 - Feldspathic pyroclast in a tuff matrix between Troutfly Lake and Beartrack Lake.

87BRB-0030 - Grey-green hornblende-phyric lapilli tuff, south of Beartrack Lake.

87BRB-0224 - Hornblende-phyric massive flow on portage between Beartrack Lake and Gardnar Lake.

87BRB-0269 - Porphyritic hornblende-pyroxene-phyric mafic tuff north of Beartrack Lake near contact with the Crossecho Lake Stock.

87BRB-0350 - Trachytiic textured crystal tuff of massive flow on west shore of Troutfly Lake.

87BRB-0534 - Hornblende-phyric tuff from east side of Laval Township near Laval-McAree Township line.

86BRB-0609 - Hornblende-phyric flow from McAree Township near McAree-Laval Township line.

86LBC-0060 - Hornblende-plagioclase-phyric tuff from Laval Township.

86LBC-0109 - Hornblende-phyric basalt from the northwest corner of McAree Township.

86LBC-0117 - Light grey plagioclase-phyric flow with biotite and hornblende from Echo Township, Goldlund Mine area.

87BRB-0235 - Laminated grey-green tuff from the south shore of Rafter Lake.

**All sample numbers are abbreviated from the standard OGS sample number, e.g., 87BRB-0029, unless otherwise stated.*

TABLE 5. GEOCHEMICAL DATA FOR GABBROS, DIORITES AND ALTERED GABBROS.

Major Oxide Listing (weight percent)

	0024*	0051	0072	0143	0290	0539
SiO_2	47.70	51.50	54.50	47.30	67.30	53.00
TiO_2	2.08	0.97	0.62	1.33	0.49	0.77
Al_2O_3	14.00	17.60	12.90	13.20	15.50	13.70
Fe_2O_3	5.40	2.72	2.06	4.00	0.71	1.80
FeO	11.50	4.53	5.12	10.20	2.33	9.52
MnO	0.21	0.12	0.15	0.20	0.03	0.19
MgO	5.20	5.99	6.99	5.69	1.07	5.36
CaO	5.76	8.61	7.15	8.80	2.02	9.92
Na_2O	3.66	3.41	3.62	2.26	5.00	2.31
K_2O	0.17	0.55	0.35	0.15	1.64	0.19
P_2O_5	0.24	0.13	0.09	0.11	0.10	0.06
CO_2	0.92	0.19	2.63	3.50	1.36	0.92
S	0.02	0.01	0.05	0.01	0.17	0.01
H_2O^+	2.98	2.53	2.21	3.11	0.72	1.81
H_2O^-	00.00	00.00	00.00	00.00	00.00	0.07
LOI	2.50	2.20	4.50	5.80	2.20	1.50
TOTAL	99.80	98.90	98.40	99.80	98.40	99.60
S.G.	2.95	2.92	2.79	2.96	2.68	3.00

Trace Element Listing

	Method	0024	0051	0072	0143	0290	0539
As	AA	1.50	4.50	2.50	-1	2	-1
Au	AA	-2 B	4 B	2 B	-2 B	2 B	-2 B
Ba	AA	50	230	94	46	410	57
Co	AA	45	29	34	48	10	41
Cr	AA	121	180	435	166	24	40
Cu	AA	73	12	87	45	47	113
Ni	AA	60	173	215	105	12	40
Pb	AA	19	17	-10	-10	22	18
Zn	AA	146	66	76	126	23	93
Be	ICP/OES	2	2	1	2	2	2
Co	ICP/OES	38	26	30	42	7	37
Cu	ICP/OES	71	6	81	40	44	106
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Ni	ICP/OES	59	177	203	103	12	44
Sc	ICP/OES	40	19	21	29	5	44
Sr	ICP/OES	123	557	281	190	259	103
V	ICP/OES	323	166	136	281	52	292
W	ICP/OES	-50	-50	-50	-50	-50	-50
Y	ICP/OES	34	12	11	26	8	20
Zn	ICP/OES	137	73	73	116	33	81
Nb	XRF	-5	-5	-5	-5	-5	-5
Rb	XRF	-5	13	8	-5	29	-5
Sr	XRF	144	549	279	208	311	125
Y	XRF	44	15	17	35	13	22
Zr	XRF	137	119	111	126	173	85
Th	XRF	-10	10	-10	-10	-10	-10
F	COLORIM	370	370	150	150	460	150

TABLE 5. CONTINUED.

Major Oxide Listing (weight percent)

	86LBC-0128	87BRB-0274	87BRB-0296
SiO_2	48.60	70.40	67.40
TiO_2	1.85	0.59	0.65
Al_2O_3	13.90	11.50	11.60
Fe_2O_3	6.10	2.91	4.51
FeO	9.85	4.13	3.19
MnO	0.24	0.06	0.08
MgO	4.83	1.79	0.66
CaO	7.73	1.25	2.38
Na_2O	3.19	3.49	6.00
K_2O	0.14	0.57	0.56
P_2O_5	0.17	0.15	0.13
CO_2	0.59	0.80	2.18
S	0.11	0.01	0.22
H_2O^+	2.22	1.48	0.47
H_2O^-	0.09	00.00	00.00
LOI	1.70	1.60	1.80
TOTAL	99.60	99.10	100.00
S.G.	3.03	2.72	2.72

Trace Element Listing

	Method	86LBC-0128	87BRB-0274	87BRB-0296
Ag	AA	-2		
As	AA	3.50	-1	-1
Au	AA		-2 B	-2 B
Ba	AA	109	93	170
Co	AA	38	6	6
Cr	AA	83	13	20
Cu	AA	83	5	-5
Ni	AA	37	-5	-5
Pb	AA	-10	22	-10
Zn	AA	137	34	67
Be	ICP/OES	-1	3	2
Co	ICP/OES	35	4	5
Cu	ICP/OES	73	3	3
Mo	ICP/OES	-10	-10	-10
Ni	ICP/OES	32	2	2
Sc	ICP/OES	37	9	11
Sr	ICP/OES	172	43	87
V	ICP/OES	396	29	35
W	ICP/OES		-50	-50
Y	ICP/OES	34	61	44
Zn	ICP/OES	103	42	66
Nb	XRF		24	24
Rb	XRF		9	21
Sr	XRF		64	112
Y	XRF		156	159
Zr	XRF		540	526
Th	XRF		-10	-10
F	COLORIM		500	500
Au	AA	-2 B		
Pt	AA	-1 B		
Pd	AA	-1 B		

87BRB-0024 - Magnetic gabbro dike intruding formation A, Neepawa Group, east of Troutfly Lake.
87BRB-0051 - Leucodiorite from centre of Beartrack Lake pluton, formation B, Neepawa Group.
87BRB-0072 - Diorite from eastern contact of Beartrack Lake pluton, formation B.
87BRB-0143 - Hornblende gabbro dike, southeast shore of Troutfly Lake, formation B.
87BRB-0290 - Quartz diorite intruding diorite phase of Beartrack Lake pluton, west of Beartrack Lake, formation B.
87BRB-0539 - Massive to plagioclase-phyric gabbro from large intrusion in southern Laval Township, formation A.
86LBC-0128 - Massive gabbro from McAree Township, formation A.
87BRB-0274 - Altered gabbro east of Gardnar Lake, formation A.
87BRB-0296 - Altered gabbro from the Mistango Main showing southwest side of Troutfly Lake, formation A.
**All sample numbers are abbreviated from the standard OGS sample number, e.g., 87BRB-0024, unless otherwise stated.*

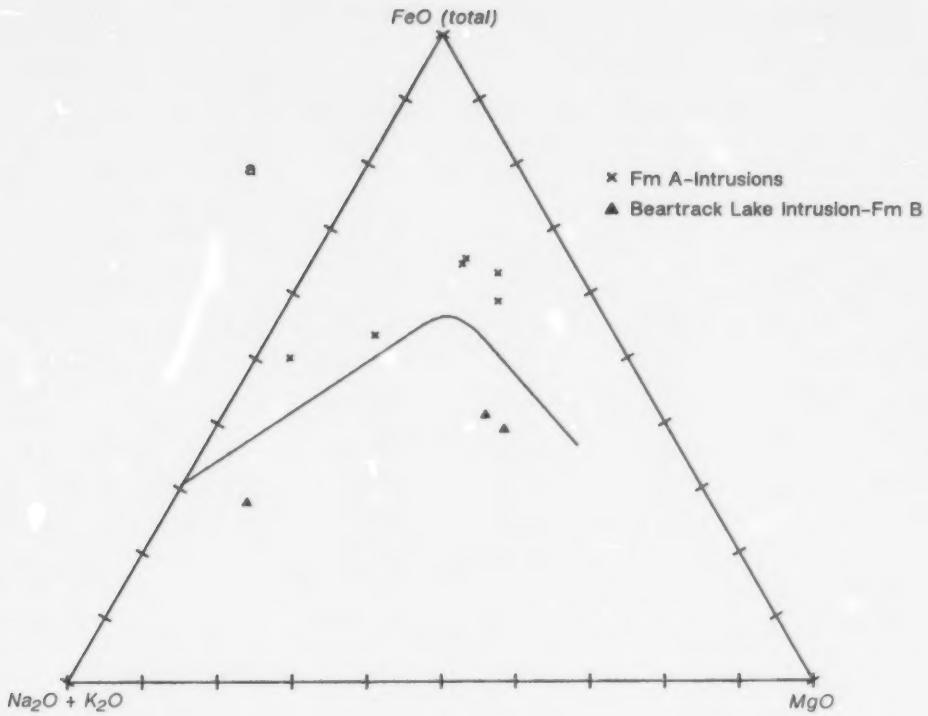


Figure 9a. *AFM plot for mafic intrusions and related rocks.*

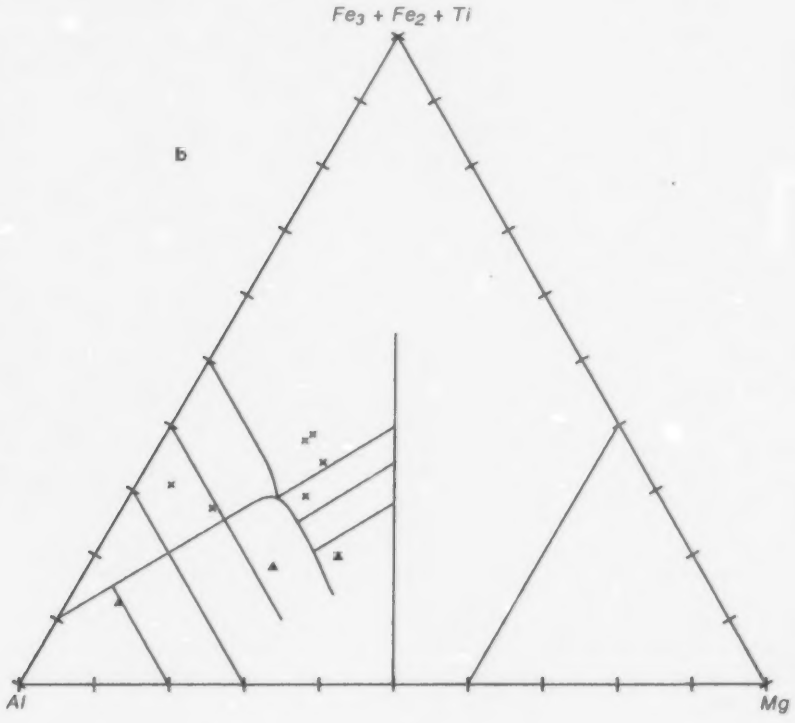
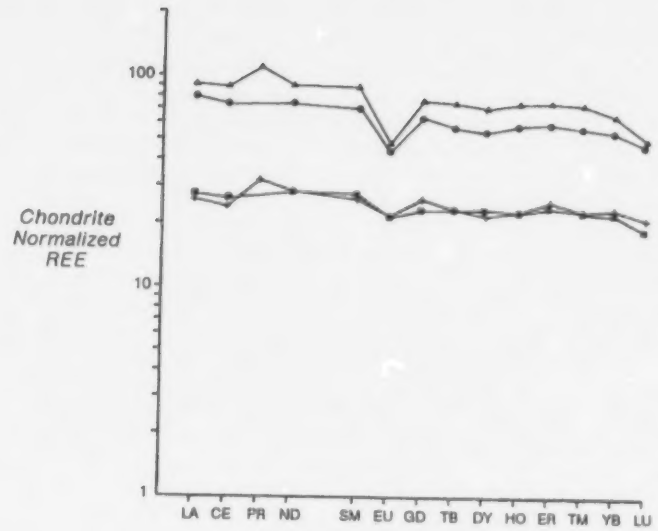


Figure 9b. *Cation plot for mafic intrusions and related rocks.*



+ 86BRB-0383*
Massive amphibolite
La/Yb 1.8

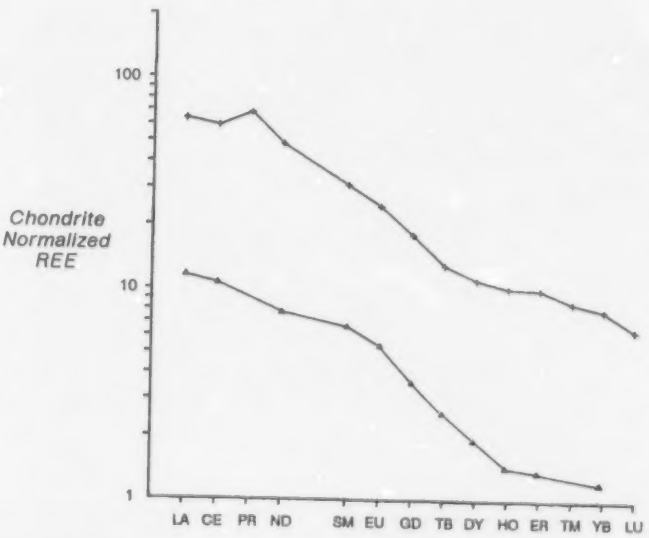
▲ 86BRB-0612*
Spherulitic dacite
La/Yb 2.3

● 86LBC-0179
Spherulitic andesite
La/Yb 2.4

■ 86LBC-0119
Plagioclase-phyric flow
La/Yb 2.0

*Geochemical data from Berger (1989)

Figure 10. *REE patterns for formation A, Neepawa Group.*



+ 86BRB-0609
Hornblende-phyric basalt
La/Yb 13.1

▲ 86BRB-0610*
Pyroxene-phyric basalt
La/Yb 15.8

*Geochemical data from Berger (1989)

Figure 11. *REE patterns for formation B, Neepawa Group.*

TABLE 6. GEOCHEMICAL DATA FOR ABRAM AND MINNITAKI GROUP FELSIC METAVOLCANICS.

Major Oxide Listing (weight percent)

	0070*	0211	0251
SiO_2	64.60	61.80	69.60
TiO_2	0.50	0.81	0.22
Al_2O_3	14.40	16.10	16.20
Fe_2O_3	1.88	1.08	0.53
FeO	4.53	5.72	1.06
MnO	0.16	0.22	0.04
MgO	1.78	1.88	0.55
CaO	5.43	4.94	3.38
Na_2O	1.36	2.68	4.53
K_2O	1.56	1.30	1.91
P_2O_5	0.07	0.16	0.06
CO_2	0.66	0.50	0.09
S	0.29	0.06	0.01
H_2O^+	2.22	1.29	0.35
H_2O^-	0.05	0.19	00.00
LOI	2.40	1.20	0.20
TOTAL	99.50	98.70	98.50
S.G.	2.81	2.75	2.67

Trace Element Listing

	Method	0070	0211	0251
As	AA	-1	-1	-1
Au	AA	-2 B	-2 B	-2 B
Ba	AA	286	282	795
Co	AA	19	13	-5
Cr	AA	91	31	17
Cu	AA	67	18	-5
Ni	AA	44	17	-5
Pb	AA	52	-10	-10
Zn	AA	78	76	21
Be	ICP/OES	2	2	1
Co	ICP/OES	16	11	1
Cu	ICP/OES	62	14	-1
Mo	ICP/OES	-10	-10	-10
Ni	ICP/OES	42	18	2
Sc	ICP/OES	12	16	2
Sr	ICP/OES	392	283	420
V	ICP/OES	142	109	24
W	ICP/OES	-50	-50	-50
Y	ICP/OES	11	16	4
Zn	ICP/OES	70	76	33
Nb	XRF	-5	5	-5
Rb	XRF	63	41	30
Sr	XRF	371	280	395
Y	XRF	13	20	7
Zr	XRF	139	195	114
Th	XRF	-10	-10	-10
F	COLORIM	220	380	380

87BRB-0070 - Crystal tuff interbedded with wacke, garnetiferous, northwest corner of Laval Township, Abram Group.
87BRB-0211 - Felsic tuff at contact between Minnitaki and Neepawa groups west of Laval Lake.
87BRB-0251 - Recrystallized, quartz-phyric tuff, Minnitaki Group, north shore of Laval Lake.
**All sample numbers are abbreviated from the standard OGS sample number, e.g., 87BRB-0070.*

Structure and Metamorphism

This section summarizes only the general structural and metamorphic features in the map area. Chorlton (1988) documented and discussed in detail the kinematic and thermal events of the Sandybeach Lake area and readers are referred to this report for a more thorough analysis of the map area.

The map area is complexly deformed with field evidence for at least three stages of deformation (Chorlton 1987). The first stage (stage 1) deformation is characterized by gently dipping to horizontal strata and structures and is best observed in a northeast-trending "belt" extending from the Laval–McAree Township line to north-central Hartman Township. A number of well-preserved stage 1 features were observed in formation A of the Neepawa Group between Troutfly and Diamond lakes in Laval Township. Here stage 1 foliation planes and schistose zones are gently southeast dipping (05 to 30 degrees) and are commonly crenulated by a northeast-trending steeply dipping foliation. Stage 1 fold axes are gently southwest or northeast plunging as are bedding-cleavage intersection lineations and mineral lineations.

Strata is gently southeast dipping in this area and as a result topography exerts a strong control on the surface distribution of the lithologies. Examination of Laval Township on Map 2534 (back pocket) shows a disjointed pattern of lithologies, most specifically gabbro in the Troutfly–Diamond lakes area. The gabbro generally occurs as gently dipping thin sheets at or near the top of hills and variolitic-spherulitic units occur along the hill flanks (*see* Figure 14). Further, several of the hills in this area plunge gently to the southwest at angles comparable to the plunge of stage 1 fold axes.

In north-central Hartman Township, an enclave of amphibolite in the Minnitaki Group shows a well-preserved subhorizontal stage 1 spaced foliation and stretching lineation (Photo 8). The strata is gently, synclinally warped and outcrops are cuesta shaped with steep drop offs on the updip side. Flexural slip along foliation planes may be responsible for this pattern.

Gently dipping tectonic fabrics and strata have been documented in several places between Sioux Lookout and the Lower Manitou Lake (Satterly 1943; Ziehlke 1975; Blackburn 1982; Page 1984). Satterly (1943) and Page (1984) documented without comment shallow to moderately dipping foliations

Photo 8. ***Subhorizontal spaced foliation in mafic amphibolite, central Hartman Township. This is a typical example of stage 1 deformational features in the map area and is interpreted to result from thrusting.***

and lineations. Page (1984) indicated shallow foliations are prevalent along the east contact of the Lateral Lake Stock. Ziehlke (1975) in discussing structural complications in the Wabigoon–Dinorwic lakes area stated:

> "Possible horst and graben type faults in the original horizontally layered volcanic pile are evident in some vertically exposed outcrops as now horizontally lying shear zones. These early faults have been folded with volcanics and now lie essentially horizontal."

Blackburn (1982) observed low angle foliations, gneissosities and lineations in the Manitou Lakes area and concluded that low angle thrust faults and overturning of strata were responsible for at least some of these features.

In the map area the stage 1 structures consistently dip to the southeast and there appears to be repetition of metavolcanic units southwest of Troutfly Lake. The Abram Group is overturned and within the Minnitaki Group overturning is locally present. Chorlton (1987) surmised that thrusting may have been responsible for the stage 1 deformation.

Stage 2 deformational features occur around the peripheries and within the margins of the granitoid stocks. Stage 2 foliations developed in the country rock are conformable to the pluton contacts and consistently dip steeply away from the intrusion. Stage 2 foliations are well developed in the Crossecho Lake and Hartman Lake stocks where they are inferred to be primary and less well developed in the Gardnar and Sandybeach Lake stocks. Steep mineral lineations within the plutons and in the surrounding country rock accompany the steep foliation. Stage 2 deformational features were observed to warp and deform stage 1 features (Chorlton 1987). Further, stage 2 features are confined only to narrow zones (100 to 300 m) around or within the plutons and this indicates deformation was synchronous with intrusion of the plutons. These contact strain aureoles, then, represent the stage 2 deformation. Age relationships are unknown among the four plutons in the map area; however, the author assumes all were intruded over a relatively short time interval.

Stage 3 deformational features are the latest, the most prominent and are regional in extent (Chorlton 1987). They are characterized by steeply dipping foliations and easterly to northeasterly trending shear zones. Stage 3 foliations vary between 015 to 065 degrees azimuth but are most commonly between 025 and 050 degrees and are always steeply dipping. In the area between Troutfly and Diamond lakes, stage 3 foliations crenulate stage 1 foliations and in several places quartz veins fill stage 3 tension gashes in the hinges of small-scale folds. Further, stage 3 foliations were observed to transpose bedding and earlier deformational features in this area which indicates stratigraphic and younging data must be carefully examined and are not always reliable.

Upright folds with subvertical axial planes were developed during stage 3 deformation and are best exposed east of Gardnar Lake. Here mesoscopic folds with moderate wavelengths of a few hundred metres are inferred to be buckle-type folds. Reversals in younging directions are not common; however, because the stage 1 deformation imparted a southeast-dipping assymetry to the strata only southeast younging is well preserved. Therefore, placement of fold axes depends largely on reversals of dips on stage 3 foliations. Due to the generally steep and therefore highly variable apparent dips recorded in the field fold axes were not placed on Map 2534 (back pocket).

Steeply dipping shear zones were formed during the stage 3 deformation and are easterly to northeasterly trending. In the map area these shear zones are most commonly developed along lithological contacts particularly in Laval Township. Here the contact between the Neepawa Group and the Minnitaki Group is marked by a shear zone (up to 50 m wide) containing carbonate and disseminated sulphides. This zone continues intermittently northeast into McAree Township where it transgresses into felsic metavolcanics where its effects gradually fade (Chorlton 1986).

Another of these northeast-trending shear zones occurs west of Gardnar Lake within the Neepawa Group. Felsic schists and sheared mafic to intermediate flows and pyroclastic rocks are locally well developed and contain disseminated pyrite with geochemically anomalous gold and tungsten. Other locally developed stage 3 shear zones in the Beartrack Lake area contain higher, potentially economic gold and are important exploration targets (*see* Economic Geology).

The Wabigoon Fault is a regional easterly trending shear zone formed during the stage 3 deformation. It is located in central Hartman Township and is characterized by an up to 200 m wide zone of metasedimentary schist along the Hartman–Zealand Township boundary. The shear zone was traced along the northern contact of the Hartman Lake Stock, where it transects the stock and where a number of subparallel shear zones are developed. East of the stock, in MacFie Township the effects of the Wabigoon Fault begin to fade as it merges with a stage 3 northeast-trending shear system (Chorlton 1987; Berger et al. 1989a, 1989b).

One of the subparallel splay faults is well exposed in the Hartman Lake Stock along Highway 72. A zone of mylonite and protomylonite from 50 to 100 m wide is sharply bounded by medium-grained, less deformed granodiorite. The shear zone is marked by pronounced foliation, grain size reduction and abundant purple fluorite along the foliation planes. Pink and white granular aplite dikes are intruded along the shear zone boundaries and small quartz ribbons (up to 1 cm) are locally developed. In thin section recrystallization is localized in numerous anastomosing zones enclosing enclaves of relatively

undeformed crystals; there is minor kinking of the plagioclase and development of quartz ribbons. These textures are indicative of mylonites.

Small, 30 cm to 1 m wide shear zones developed in other outcrops of the Hartman Lake Stock along Highway 72 show that foliation is dextrally rotated in the mylonites and from this the main sense of motion on the Wabigoon Fault is inferred to be dextral. At one location small north- to northeast-trending fractures sinistrally offset the easterly foliation which implies early main dextral motion and later minor sinistral motion. However, Chorlton (1986) determined that the main motion on the northeast shear system in MacFie and McAree townships was predominantly sinistral with a later dextral component. If the Wabigoon Fault and the northeast shear system are regarded as stage 3 features developed at approximately the same time, then the apparent discrepancies can be regarded as resulting from conjugate systems. Further, where the two systems merge, east of the map area, a strong dip-slip component expressed by steeply plunging lineations is developed and this indicates that movement along the shear zones is more complex than a simple two-dimensional analysis might indicate (Chorlton 1986). Stage 3 deformation was caused by northwest-southeast compression which may have resulted from intrusion of large granitic batholiths.

In the Dryden area, there is an abrupt change in deformation styles, metamorphism and lithologies across the Wabigoon Fault (Blackburn et al. 1985). These data have led Breaks, Bond and Stone (1978) and Blackburn et al. (1985) to conclude that the Wabigoon Fault is the boundary between the English River Subprovince and the Wabigoon Subprovince. In the map area lithologies are continuous across the fault, deformation styles are the same throughout the area and metamorphic patterns are very complex. These data indicate the Wabigoon Fault is not a suitable subprovincial boundary and the entire map area is interpreted to lie within the Wabigoon Subprovince.

Finally, stage 3 deformation has resulted in fracturing of structurally competent bodies. Quartz and quartz-tourmaline veins fill stage 3 fractures in all the granitoid plutons and are conjugate to the main northeast foliation. Metagabbro and altered metagabbro sheets in the Troutfly Lake area are highly fractured and filled by auriferous and pyritic quartz veins. A metadiorite pluton at Beartrack Lake has undergone stage 3 fracturing and siliceous, auriferous and pyritic fluids have penetrated these structures. It is these stage 3 fractures and shear zones that host and control gold mineralization in the map area.

North-trending brittle fractures are common east of Rafter Lake and several prominent fault scarps and airphoto lineaments mark their locations. Quartz veining and tectonic breccias are common in these structures but as yet gold mineralization is unknown. These faults have locally disrupted lithologic continuity but they do not appear to be geologically important structures.

METAMORPHISM

Most of the metamorphic information for the map area is contained within the Minnitaki Group and Abram Group metasediments where diagnostic mineral assemblages and textures provide information on peak metamorphic temperatures and timing of metamorphic events. However, important data was also obtained from the mafic metavolcanics, the felsic plutons and the granitic pegmatite-aplite suite.

Most commonly staurolite, cordierite, andalusite and garnet are present in the pelitic metasediments along with ubiquitous biotite and muscovite. Sillimanite and microcline are less common and chlorite is rare or absent. These minerals indicate that upper greenschist to amphibolite grade was obtained by most of the metasediments (Winkler 1979). Biotite, garnet, the abundance of blue-green amphibole and the relative paucity of chlorite in the mafic metavolcanics indicates similar upper greenschist to lower amphibolite grade affected most of these rocks. Only metavolcanics in the southeast corner of Hartman Township contain abundant chlorite and epidote indicative of low to middle greenschist facies (Winkler 1979).

Around the periphery of the Sandybeach Lake Stock and along a southwest-trending zone in Hartman Township, metatexite, granitic pegmatite-aplite, sillimanite, microcline and orthogneiss are most abundant. Sillimanite and garnet in the pegmatite indicate that the pegmatite is peraluminous (Chappell and White 1974) and most likely derived by anatexis of the metasediments (Winkler 1979). Discontinuous melanosome rims on the leucosome in the metatexite indicate derivation from partial *in situ* melting of the host metasediments (Brown 1973). This zone of high temperature minerals and partial melting represents the peak metamorphic mineral assemblage in the map area and minimum temperatures in this "thermal ridge" may have ranged from 550° to 660°C (Winkler 1979; Pirie and Mackasey 1978; Berger 1989).

Evidence for the relative timing of the metamorphism with respect to deformation is best preserved in the metasediments. Staurolite, garnet and less commonly muscovite occur in two distinct crystal habits. Staurolite, now converted to white mica, is commonly crenulated and rotated by stage 3 foliation planes indicating pre- to syn-stage 3 crystallization. However, staurolite also occurs as large poikiloblastic crystals showing very little evidence of deformation and this suggests post to late syn-stage 3 metamorphism. Similarly, muscovite commonly forms bladed crystals aligned parallel to bedding or stage 1 foliation planes. In this habit they are crenulated by stage 3 foliation and new bladed muscovite may grow along these foliation planes. Less commonly muscovite occurs as

large euhedral porphyroblastic crystals and commonly overgrows quartz and earlier formed phyllosilicates. In one place euhedral muscovite overgrows staurolite converted to white mica and again this implies a late- or post-stage 3 muscovite crystallization. Garnet commonly occurs as large helicitic anhedral to euhedral crystals showing little evidence of deformation. In a few places, however, chlorite pseudomorphs after garnet and rotated trains of inclusions ("snowball garnet") indicate a pre- to syn-stage 3 crystallization history. Chorlton (1987) observed that staurolite and andalusite overprinted stage 1 foliation and formed augen within the stage 3 crenulation. Cordierite porphyroblasts commonly conform to the stage 3 structures which indicates syn- to post-stage 3 crystallization (Chorlton 1987). Microcline in metasediments and felsic metavolcanics and hornblende in the mafic wackes and mafic metavolcanics also indicate relative timing of the metamorphism. Microcline occurs as large anhedral to euhedral porphyroblasts that conform to and overgrow stage 3 foliation indicating syn- to post-stage 3 crystallization. Hornblende in the more mafic members of the Minnitaki Group are anhedral to euhedral blue-green porphyroblasts that are largely undeformed.

Neosome in metatexite is commonly folded and deformed by the stage 3 structures which indicates partial melting occurred prior to or during the stage 3 deformation. However, the granitic pegmatite-aplite suite which was also formed by anatexis is generally undeformed and this indicates partial melting continued after stage 3 deformation. Xenoliths are apparently unrotated, only small-scale banding is present and microscopically metamorphic minerals are relatively unstressed, which indicate the pegmatite-aplite was intruded post tectonically. In fact, most of the undeformed late- to post-stage 3 metamorphic minerals and textures are localized along the southwest-trending zone in Hartman Township previously referred to as a "thermal ridge". This "ridge" extends northeast into McAree Township where similar textures occur in the core of a dome and along the north contact of the Sandybeach Lake Stock (Berger 1989).

Based on the field and laboratory evidence, metamorphism in the map area is complex and spanned the deformational stages. Crenulated staurolite and andalusite overprint stage 1 foliation and clearly indicate these minerals were stable prior to stage 3 deformation. They possibly were formed in the contact thermal aureole developed around the Sandybeach Lake Stock (Berger 1989). That the earlier formed staurolite are overgrown by muscovite porphyroblasts indicates the staurolite was converted to white mica then subjected to a second metamorphism of equal or greater temperatures. Thus it appears that amphibolite grade metamorphism was attained during stage 2 intrusion of the granitoid stocks and a late- to post-stage 3 metamorphism culminating in extensive partial melting that subsequently affected the map area. The stage 2 metamorphism is restricted to the thermal aureoles around the plutons and in places removed from these stocks, such as in the Abram Group, only the late- to post-stage 3 metamorphism is apparent. As to how the "thermal ridge" developed requires further work. Perhaps crustal thinning due to stage 1 thrusting created a higher geothermal gradient along an axis parallel and downdip of the thrust plane.

ALTERATION

Three types of hydrothermal alteration were identified in the map area. A pervasive but disseminated magnetite-calcite or locally sericite-calcite alteration is inhomogeneously developed throughout the Neepawa Group and along the contact of the Neepawa Group with the Minnitaki Group. Feldspathic altered gabbro sheets and spherulitic-variolitic rocks are most susceptible; however, all mafic and intermediate rocks are more or less affected. This type of alteration is most obvious in northeast-trending shear zones and locally magnetite is profuse enough to deflect a compass needle. Northeast of the map area ankerite-sericite-chlorite schists replace the magnetite-calcite and this is attributed to lower metamorphic grade below the biotite isograd (Chorlton 1987). In the map area idiomorphic magnetite commonly overprints an earlier amorphous magnetite-iron oxide precursor. This indicates the presence of magnetite is as much a function of primary iron enrichment in parts of the Neepawa Group as due to hydrothermal alteration (Chorlton 1988; *see* Geochemistry).

The second type of alteration to affect the map area is widespread tourmalinization. This type of alteration affects all rock types and is most pronounced north of the Wabigoon Fault. Quartz-tourmaline veins commonly fill stage 3 fractures and are most abundant in the felsic plutons, the granitic pegmatite aplite suite and in the amphibolites west of Hartman Lake.

All zones of weakness including foliated and schistose rocks or originally porous material such as pillow rims, scoriaceous fragments, matrices of mafic pyroclastic deposits or pillow breccias and sandy wacke beds are susceptible to tourmalinization. Radial aggregates of tourmaline needles up to 1 cm diameter are developed in several places as are thin tourmaline stringers. In many places in the metasediments and felsic metavolcanics, tourmaline is microscopically aligned along original bedding planes or in stage 3 deformation foliation planes. Southwest of Troutfly Lake, tourmalinization is locally profuse and accompanies quartz and scheelite veins in quartz-feldspar-phyric dikes. In this same general area tourmaline accompanied by albite and chlorite occurs in stage 1 schistose zones and pillow selvages. The stage 1 schistosity is crenulated, folded and locally transposed by the stage 3 foliation. Albite porphyroblasts overgrow the stage 1 schistosity and are conformable with the stage 3 crenulation. Chlorite and tourmaline

clearly overprint all structures and occur as well formed needles and rosettes. In all places tourmaline crystals are euhedral laths or basal sections and are either localized in stage 3 structures or overprinting all fabrics. This indicates the tourmalinization occurred synchronous with the late- to post-stage 3 metamorphic event.

The third type of alteration namely silicification accompanied by pyritization (± arsenopyrite) is developed only locally and is commonly associated with gold mineralization. This alteration is associated with stage 3 fractures or shears and the alteration zones are potentially auriferous and good exploration targets. Tourmaline, carbonate, sericite and albite are usually present; magnetite and scheelite are less common. Sulphide content in these zones varies between trace and 75 percent; however, correlation between gold and sulphide content is as yet unknown. This type of alteration is most common in the Beartrack Lake area; however, it may occur wherever stage 3 structures are well developed.

Economic Geology

Gold has been the most actively sought-after economic commodity in the map area. Hurst (1933) reported exploration was active in the entire Sioux Lookout area in the early 1900s; however, no significant discoveries were made at this time. Gold mineralization was discovered in Echo Township (northeast of the map area) in 1941 and subsequent exploration led to the discovery of the Goldlund deposit (Page and Christie 1980a, 1980b). Between 1946 and 1952 extensive exploration was carried out in the map area resulting in the discovery of three separate gold showings. Amant Gold Mines Limited and Calder Bousquet Gold Mines Limited explored auriferous quartz veins at the south end of Troutfly Lake. Graham Bousquet Gold Mines Limited discovered, trenched and diamond drilled two gold showings located at either end of a subvolcanic metadiorite intrusion in the Beartrack area. More recent work by Mistango Consolidated Resources Limited (1982–present) has focussed on the gold showing at the south end of Troutfly Lake.

Exploration for base metals began in the 1960s (Page and Christie 1980a, 1980b) and has been sporadic since that time. A number of companies have flown airborne electromagnetic surveys and have tested selected geophysical anomalies by diamond drilling. Lead-zinc-silver mineralization in southwestern Laval Township was explored by Hollinger Mines Limited in 1978 and is the most significant base metal discovery to date.

An airborne radiometric survey was carried out in 1969 by C. Morton over the southeastern part of Laval Township; however, no anomalous radioactivity was discovered and no follow-up work was reported.

Gold is the most important economic mineral in the map area and mineralization is controlled by structures related to the third stage deformation (Chorlton 1987). Northeast-trending shear zones or east-northeast- and north-northeast-trending fractures and shears localize the known gold showings in the map area and are potential exploration targets wherever they are well developed. Where these structures encounter structurally competent bodies, fracturing may occur and these sites are particularly susceptible to gold mineralization. In the map area fractured mafic subvolcanic intrusions and felsic flows within the Neepawa Group are preferred gold hosts and future exploration should concentrate wherever these rocks occur.

Previous base metal exploration has focussed on testing airborne geophysical anomalies near the contact of the Neepawa and Minnitaki groups. Most diamond-drill holes in this area encountered trace amounts of copper, zinc and silver mineralization within sulphide facies ironstones or graphitic-argillaceous schists. Additionally sulphide-rich interpillow material collected by members of the field crew from this area was enriched in copper and zinc indicating continued exploration of this horizon is warranted. Known lead-zinc-silver mineralization in the map area is situated entirely within formation A of the Neepawa Group and hosted by or near the contact of felsic spherulitic flows and pyroclastic rocks. In almost all surface exposures of spherulitic rocks, some sulphide minerals (usually pyrite and chalcopyrite) were observed and this indicates spherulitic horizons are prospective base metal targets.

Numerous samples from known mineral showings and from other prospective areas were collected by members of the crew during the field season and were analyzed by the Geoscience Laboratories Section, Ontario Geological Survey, Toronto (Tables 7a and 7b). Other assay values referred to in this section were obtained from diamond-drill logs and reports filed for assessment work credits; these reports can be obtained from Assessment Files Research Offices (AFRO) in Toronto and Kenora.

DESCRIPTION OF PROPERTIES

AMANT GOLD MINES LIMITED (1951)

Amant Gold Mines Limited held two noncontiguous claim groups in Laval Township in 1952 (No. 1, Figure 12). One claim group covered auriferous quartz veins exposed on an island at the south end of Troutfly Lake. These veins which are described in detail under Mistango Consolidated Resources Limited (*see* below) were trenched by Amant Gold Mines Limited but results are not known and the author assumes they were discouraging as the claims were allowed to lapse.

The second group of claims was located along the eastern boundary of Laval Township approximately 1 to 1.5 km east of Troutfly Lake (Figure 12). Here Amant Gold Mines Limited dug a number of trenches on quartz veins and sparse sulphide mineralization exposed in what is referred to as a "felsite dike". Four diamond-drill holes (aggregate 269.4 m), each centred approximately 23 m apart, tested the ground under the trenches. From the diamond-drill logs, quartz porphyry, acid tuff, chloritic schist and granodiorite were the main rock types encountered and these rocks were silicified and injected with numerous quartz veins. Sulphide mineralization occurs throughout all lithologies in unspecified amounts and identified minerals are pyrite, pyrrhotite, sphalerite, chalcopyrite, galena and possibly the lead telluride altaite. Several assay values were reported with the highest being 0.005 ounce gold per ton over 0.21 m, 0.09 ounce silver per ton over 0.33 m and 0.07 percent zinc over 0.46 m. Additional silver values in the range 0.02 to 0.06 ounce silver per ton were encountered throughout the drill holes indicating the pres-

TABLE 7A. RESULTS OF ASSAYS FOR LAVAL TOWNSHIP.

Sample No.	Au (ppb)	Ag**	Pt (ppb)	Pd (ppb)	Cu	Zn	Pb	Ni	As	W	Co	Comments
0026*	3	<2	-	-	102	23	-	-	-	-	-	pyrrhotitic spherulitic rock east of Troutfly Lake
0031	8520	5	-	-	-	345	-	-	400	<50	-	silicic-sericitic metadiorite 10% pyrite, 5% magnetite, Beartrack South
0032	31670	6	-	-	550	2860	50	-	1000	-	-	50 to 75% pyrite with sphalerite in siliceous, chloritic matrix, Beartrack South
0034	300	<2	-	-	31	945	-	-	350	-	-	sericite-silica schist up to 30% pyrite, Beartrack South
0035	70	<2	-	-	115	-	-	-	-	-	-	quartz vein with chalcopyrite 15 m east from Beartrack south trench
0041	<4	<2	-	-	123	107	-	-	-	-	-	chlorite-talc schist with 5 to 10% pyrite and trace malachite
0044	<2	<2	-	-	76	17	-	-	-	-	-	pyritic chert interbed in mafic metavolcanics and variolites
0049	2	<2	-	-	6	15	-	-	-	<50	-	weakly silicified metadiorite with nil sulphides and brown carbonate
0052	2	<2	-	-	-	-	-	-	-	-	-	quartz and tourmaline vein in foliated metadiorite, Beartrack Lake
0053	40	<2	-	-	8	22	-	-	-	-	-	4 m wide silicified zone in metadiorite with trace pyrite, Beartrack Lake
0055	<2	<2	-	-	-	-	-	-	-	-	-	15 cm quartz and tourmaline vein west of Beartrack Lake
0058	<2	<2	-	-	35	76	-	-	-	-	-	2 to 5% pyrite in schistose metagabbro with carbonate west of Beartrack Lake
0060	5	<2	-	-	345	21	-	-	10	<50	-	pyritic quartz vein with tourmaline, Beartrack North
0061	<2	<2	-	-	-	-	-	-	2.5	<50	-	quartz vein material with <1% pyrite, has ankerite and tourmaline, Beartrack Lake
0062	340	<2	-	-	245	44	-	-	750	-	-	silicified schist with up to 20% pyrite, Beartrack North
0063	3	<2	-	-	-	-	-	-	5.0	-	-	chloritic mafic schist, trace pyrite, Beartrack North showing
0074	40	<2	-	-	143	91	-	-	-	<50	-	rusty felsic schist 1 to 2% pyrite in part quartz-carbonate altered
0075	4	<2	-	-	40	147	<10	-	-	-	-	rusty and chloritic mafic schist 5 to 10% pyrite; trace magnetite
0083	4	<2	-	-	-	-	-	-	-	<50	-	quartz and tourmaline veins in bleached quartz-feldspar porphyry dike
0088	11	<2	-	-	196	12	<10	-	-	-	-	graphitic and pyritic interflow metasediments in basalts
0092	4	<2	-	-	78	125	<10	46	-	-	-	rusty-pyritic interpillow material west of Diamond Lake
0094	<2	<2	-	-	111	237	<10	-	-	-	-	rusty flow breccia immediately west of Diamond Lake
0112	<2	<2	-	-	50	180	-	-	-	-	-	1 to 5% pyrite in mafic to intermediate flow west of Troutfly Lake
0133	<2	<2	-	-	-	-	-	-	-	-	-	1 to 5% pyrite in sheared mafic metavolcanics, Troutfly Lake
0137	<2	<2	-	-	-	-	-	-	5.5	-	-	quartz veining and pyritic, carbonatized metadiorite from Mistango showing
0147	<2	<2	-	-	-	-	-	-	5.5	<50	-	biotitic and calcitic mafic schist west of Beartrack Lake
0170	50	3	-	-	1180	6720	-	52	-	<50	-	pyritic, interpillow material near contact with wackes
0184	<2	<2	-	-	-	-	-	-	-	<50	-	quartz vein in monzonitic dike, north shore Diamond Lake
0212	<2	<2	-	-	22	67	-	8	-	-	-	garnet-hornblende amphibolite in felsic metavolcanics and wackes
0220	1400	-	<1	<1	4840	905	-	16	-	-	144	10% pyrrhotite 25 cm wide shear zone in metadiorite with pyrite, chalcopyrite and magnetite south of Beartrack Lake
0222	130	-	<1	<1	3070	570	-	60	-	-	62	1 m wide shear zone in metadiorite with pyrite, chalcopyrite, and malachite

TABLE 7A. CONTINUED.

Sample No.	Au (ppb)	Ag**	Pt (ppb)	Pd (ppb)	Cu	Zn	Pb	Ni	As	W	Co	Comments
0235	3	<2	-	-	-	-	-	-	1.5	<50	-	large 1.5 m wide quartz vein in North-South shear on shore of Rafter Lake
0232	2	-	<1	<1	143	-	-	<5	-	-	-	massive amphibolite with 2 to 5% pyrrhotite and minor quartz veining
0264	9	<2	-	-	44	18	-	-	2.0	-	-	5 m wide felsic schist with up to 20% pyrite and carbonate
0265	13	<2	-	-	25	31	-	-	5.0	-	-	muscovite-sericite schist containing 2 to 5% pyrite
0280	<2	<2	-	-	36	280	26	-	-	-	-	graphitic schist from Hollinger Mines Ltd. ddh Lb1-3-78-204 feet
0288	<2	<2	-	-	31	22	-	-	2.5	<50	-	quartz vein with tourmaline, no pyrite from shear zone in quartz diorite
0289	<2	<2	-	-	-	-	-	-	3.5	<50	-	quartz-tourmaline vein material with host quartz diorite, 5 to 10% pyrite
0289A	<2	<2	-	-	-	-	-	-	18.0	525	-	quartz diorite with scheelite-tourmaline veinlet, 5% pyrite
0295	<2	<2	-	-	136	740	<10	-	-	-	-	composite sample of graphitic schist with 20% pyrite from abandoned ddh core
0318	2	<2	-	-	27	-	<10	-	1.0	<50	-	quartz-carbonate halo with large portions of unaltered metagabbro pyrite and galena
0319	8	<2	-	-	17	-	550	-	1.0	<50	-	quartz-carbonate vein with pyrite and galena in alteration halo
0320	<2	<2	-	-	<5	-	28	-	1.0	<50	-	mixed quartz-carbonate veins and metagabbro
0321	5	<2	-	-	75	-	850	-	1.5	<50	-	intermixed quartz-carbonate vein and gabbro with pyrite and galena
0322	<2	<2	-	-	60	-	700	-	1.0	<50	-	as 321 with more carbonate
0323	<2	<2	-	-	12	-	26	-	1.5	<50	-	mixed quartz and carbonate in metagabbro-pyritic
0324	<2	<2	-	-	54	-	100	-	<1	<50	-	as 323 with less carbonate
0363	<2	<2	-	-	-	-	-	-	<1	<50	-	carbonatized and silicified metadiorite with 1 to 2% pyrite, "grandiorite" type
0400	<2	<2	-	-	25	168	28	-	1.0	-	-	quartz vein with pyrite in rusty-carbonate altered felsic metavolcanic
0401	<2	<2	-	-	59	111	62	-	1.5	-	-	rusty-carbonate altered felsic metavolcanic with pyrite
0502	<2	<2	-	-	-	-	-	-	-	<50	-	quartz-tourmaline vein intruding Crossecho Lake Stock
0529	<2	<2	17	14	107	-	-	12	-	-	-	rusty metagabbro with 1 to 2% pyrrhotite south of Diamond Lake
0909	<2	<2	-	-	-	-	-	-	1.0	<50	-	quartz-tourmaline veinlets in quartz-feldspar porphyry dike, north shore Diamond Lake

All sample numbers are abbreviated from the standard OGS sample number, e.g., 87BRB-0026.
**Note all values in ppm unless otherwise stated.*

TABLE 7B. RESULTS OF ASSAYS FOR HARTMAN TOWNSHIP.

Sample No.	Au (ppb)	Ag**	Pt (ppb)	Pd (ppb)	Cu	Zn	Pb	Ni	As	W	F	Be	Mo	Li	Ta	Nb	Sn	Comments
0002*	<2	<2	-	-	110	-	-	-	-	<50	-							sheared mafic metavolcanic with pyrite and chalcopyrite
0011	<2	<2	-	-	-	-	-	-	-	<50	-							quartz-tourmaline vein in Sandybeach Lake Stock
0015	<2	<2	-	-	-	-	-	-	-	-	-							quartz vein in mafic metavolcanic
0096	<2	<2	14	14	70	100	<10	-	-	-	-							pyritic massive basalt
0097	<2	<2	9	6	56	-	-	24	-	-	-							pyritic massive basalt
0201	14	<2	5	7	41	35	-	<5	-	<50	-							gossan, true "ironcap" rock
0202	17	<2	<1	14	101	25	-	30	-	<50	-							massive pyrrhotite + pyrite 1.5 m below gossan
0203	7	<2	<1	2	71	31	-	10	-	<50	-							regolith .5 to 1 m below gossan
0204	16	<2	<1	7	73	<10	-	<5	-	<50	-							as 203 but 5 m along strike
0205	<2	<2	12	8	72	122	-	40	-	<50	-							stringer sulphides in mafic schist
0206	7	<2	<1	1	73	22	-	18	-	<50	-							massive pyrrhotite + pyrite 5 m from 202
0241	-	-	-	-	-	-	-	-	-	<50	<50	-	<10	<8	<10	78	17	white pegmatite
0245	-	-	-	-	-	-	-	-	-		130	65	<10	<4	74	152	115	white pegmatite dike
0247	-	-	-	-	-	-	-	-	-	<50	1550	2	<10	<8	-	-	1	fluorite in mylonitized granodiorite
0259	<2	<2	-	-	-	-	-	-	-	<50	300	-	<10	-	-	-	1	sheared granodiorite with pyrite
0328	<2	<2	-	-	<5	-	<10	-	<1	<50	-							barren quartz vein in mafic amphibolite
0330	<2	<2	-	-	95	162	-	-	9.0	-	-							quartz vein + amphibolite + trace pyrite
0331	<2	<2	-	-	396	164	-	-	<1	-	-							rusty biotitic amphibolite

All sample numbers are abbreviated from the standard OGS sample number, e.g., 87BRB-0002.
***Note all values in ppm unless otherwise stated.*

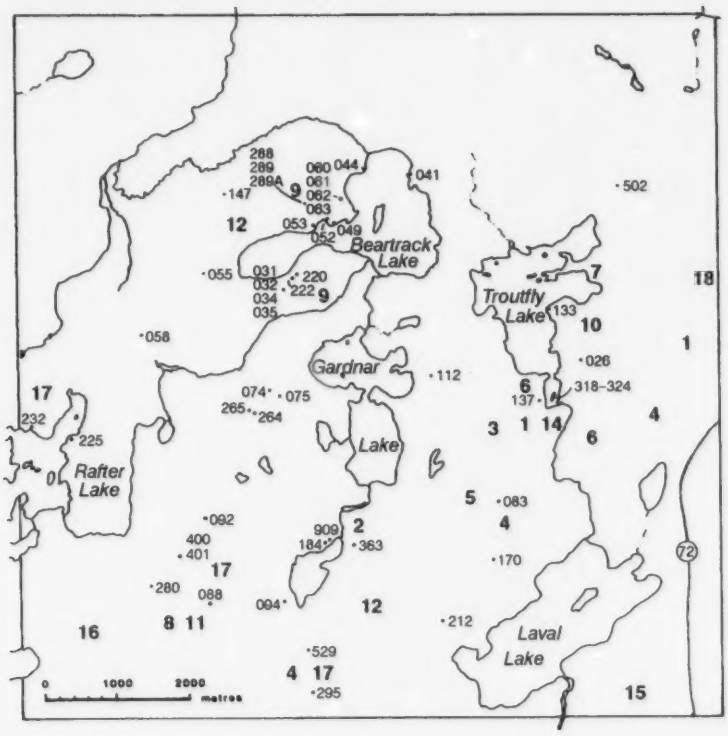


Figure 12. *Property and assay sample location map for Laval Township.*

ence of widespread low grade mineralization in this area. Amant Gold Mines Limited carried out no further exploration and the claims were allowed to lapse.

Traverses by members of the field crew were carried out in the general area of Amant's diamond drilling; however, neither diamond-drill sites nor trenches were located. This area lies near the contact between the Neepawa Group metavolcanics and the Minnitaki Group metasediments and most exposed rocks are highly deformed wacke intruded by numerous quartz-feldspar porphyritic to equigranular dikes and sills. The acid tuffs encountered by Amant Gold Mines Limited most likely belong to the felsic metavolcanic member of formation A of the Neepawa Group and as such would generally be very fine grained and white resembling tuff that occurs to the northeast of the map area (Berger 1989). Northeast-trending shearing related to the third stage of deformation is common along the contact of the Neepawa and Minnitaki groups and may localize mineralization where fracturing of structurally competent bodies is developed.

BILLITON METALS CANADA INCORPORATED (1985)

In 1984, Billiton Metals Canada Incorporated (No. 2, Figure 12) acquired an option on 92 contiguous claims in Laval Township from Mistango Consolidated Resources Limited (No. 14, Figure 12). Grid lines were cut over the entire property and ground VLF-EM (Very Low Frequency Electromagnetic), total field and gradiometer magnetic surveys were carried out and were followed by a geology and reconnaissance sampling survey. Geophysical results indicate a number of northeasterly trending magnetic highs which are in places coincident with VLF conductors. The geology survey indicates the property is underlain predominantly by mafic metavolcanics with subordinate felsic metavolcanics and clastic metasediments. Gabbroic dikes and sills, numerous felsic dikes and sills and phases of the Gardnar Lake Stock intrude the metavolcanics and metasediments. Numerous samples were collected and analyzed for gold, silver and tungsten, and when combined with the mapping, six potential gold and/or base metal targets were recognized.

These six targets include an "exhalative" chert and massive pyrite-pyrrhotite horizon which contains up to 3.6 ppm silver, pyritic felsic tuffs that contain elevated zinc (100 ppm) and copper (95 ppm), shear zone hosted quartz veins that contain up to 5 ppb gold, 0.9 ppm silver and 16 ppm tungsten, quartz veins in metasediments that contain up to 190 ppb gold, fractured and hydrothermally altered "granodiorite" dikes containing sulphide-bearing quartz veins that returned up to 10 ppm gold and 86.5 ppm (2.5 ounces per ton) silver, and altered felsic porphyry dikes which contain up to 55 ppb

gold, from 0.2 to 3.7 ppm silver and from 2 to 900 ppm tungsten. Apparently Billiton Metals Canada Incorporated did not consider any of these targets sufficiently encouraging as no further work was carried out and the property was returned to Mistango Consolidated Resources Limited.

Several traverses were carried out by members of the survey crew over the claim group optioned by Billiton Metals Canada Incorporated. The only mineralized target not examined by the present survey crew was the "exhalite" horizon which was not located.

Pyritic felsic tuffs and schists occur east of Troutfly Lake near the contact with clastic metasediments and west of Gardnar Lake where they are structurally interleaved with hornblende-phyric intermediate flows and pyroclastic rocks. East of Troutfly Lake the felsic schists are part of a larger felsic metavolcanic deposit and contain carbonate as well as sparsely disseminated pyrite. These schists occur intermittently throughout this environment wherever northeast-trending shear zones are well developed and may possibly be auriferous where accompanied by quartz veining or pervasive silicification. West of Gardnar Lake, felsic schists are well developed and localized in northeast-trending shear zones. Here pyrite is more abundant, locally up to 20 percent, and randomly selected samples from this area (074, 264, 265, Figure 12) returned up to 40 ppb gold, 143 ppm copper and 91 ppm zinc. Again if quartz veining or pervasive silicification is present, gold values may possibly increase.

Quartz veining in metasediments is very common not only on the property optioned by Billiton Metals Canada Incorporated but throughout all metasediments. Typically these veins are narrow (2 to 5 cm) and metres to tens of metres long. They generally strike parallel to the northeast-trending third stage deformation foliation but contorted first stage quartz veining is evident in many places. Elevated gold values may occur within these veins. The veins, however, are generally too small and too widely spaced to be economically significant.

The shear zone hosted quartz veins referred to by Billiton Metals Canada Incorporated are the auriferous veins previously explored by Amant Gold Mines Limited on an island in the south end of Troutfly Lake. These veins which are discussed in detail under Mistango Consolidated Resources Limited are a good example of veining hosted in a fractured, structurally competent body (metagabbro).

Billiton refers to carbonatized and locally silicified "granodiorite" dikes hosting disseminated pyrite and crosscutting quartz stringers as being potential gold targets. This environment was actively being explored at the time of writing (December 1987) and is fully discussed under Mistango Consolidated Resources Limited (No. 14, Figure 12).

Numerous felsic dikes were observed by the present field crew on the property optioned by Billiton Metals Canada Incorporated. Most of these dikes are either feldspar porphyritic, quartz-feldspar porphyritic or equigranular monzonite to tonalite. A few of these dikes are highly altered with abundant quartz, carbonate and/or tourmaline stringers carrying sparsely disseminated pyrite. These dikes are aligned along northeast foliation planes or along east-northeast structures and contain elevated gold, silver and tungsten which is indicative of hydrothermal activity of typical Archean lode gold deposits (Roberts 1987; Kerrich and Hodder 1982).

CALDER BOUSQUET GOLD MINES LIMITED (1951)

In 1950–51, Calder Bousquet Gold Mines Limited (No. 3, Figure 12) held 20 unpatented mining claims in Laval Township adjoining Amant Gold Mines Limited (*see* above). Calder Bousquet personnel carried out surface exploration on the claim group which consisted of geological mapping on a cut grid supplemented by samplings of quartz veins and mineralized "quartz-feldspar porphyry" dikes. Calder Bousquet Gold Mines Limited did not report carrying out any diamond drilling or follow-up work on this property.

"Quartz-feldspar porphyry" dikes occur throughout the property and based on descriptions by Calder Bousquet Gold Mines Limited some of these dikes include the silicified and carbonatized metagabbro sheets that are known to occur in this area. Pyrite, galena and chalcopyrite were observed in quartz veins in several of these intrusions and a gold assay of 0.12 ounce gold per ton was returned from one of these veins.

The Calder Bousquet property remained dormant from 1951 until Mistango Consolidated Resources Limited (No. 14, Figure 12) acquired a large package of ground covering this area in 1982. At this time renewed exploration carried out under option by Billiton Metals Canada Incorporated (*see* above) established that geology favourable to gold mineralization did exist. The site of diamond drilling attributed to Calder Bousquet by Beard and Garrett (1976) and Neilson and Bray (1981) could not be located. The confusion arises because diamond-drill results from Eclund Gold Mines Limited (No. 6, Figure 12) and from Graham Bousquet Gold Mines Limited (No. 9, Figure 12) were attributed to Calder Bousquet Gold Mines Limited and listed under "Calder Bousquet Prospect" (Beard and Garrett 1976).

As previously mentioned there is no report of Calder Bousquet Gold Mines Limited performing diamond drilling on the property.

Details of mineralization are described under Mistango Consolidated Resources Limited (No. 14, Figure 12).

CANADIAN NICKEL COMPANY LIMITED (1970–71)

Canadian Nickel Company Limited (No. 4, Figures 12 and 13) carried out exploration directed towards the discovery of base metal mineralization in Laval and Hartman townships between 1970 and 1971. Canadian Nickel Company Limited acquired four geographically separated properties and each is discussed proceeding from the southernmost property to the northernmost property (refer to Figures 12 and 13). On the southernmost property one diamond-drill hole (240.8 m) was sited to test massive pyrite and pyrrhotite mineralization exposed in a roadcut along Highway 72. Massive and disseminated sulphides hosted in meta-andesite and intercalated with wacke, quartz-feldspar porphyry and granite were intersected; however, only trace amounts of chalcopyrite were discovered. No further work was reported and the property was allowed to lapse.

During the field season the massive sulphide mineralization was examined and sampled at several places along Highway 72. The mineralization occurs entirely within sheared mafic metavolcanics and is composed of pyrite, pyrrhotite and chlorite with lesser amounts of graphite and quartz. A gossan approximately 12 m long by 1 m wide by 1.5 m thick is developed directly over the massive sulphides and numerous rusty zones occur all along the outcrop. The mineralization is localized along foliation planes and appears to be structurally controlled. Airborne electromagnetic anomalies (Ontario Geological Survey 1987e) that occur directly over the mineralization and to the east are aligned parallel to the main foliation direction supporting a structural control interpretation. Six representative samples were collected (by the field crew) and analyzed (samples 201 to 206 inclusive, Figure 13, Table 7b). Base metal values are relatively low with maximum copper at 101 ppm, zinc at 122 ppm and nickel at 40 ppm. Precious metal values, however, are generally more encouraging with average gold values of approximately 10 ppb, maximum platinum values of 12 ppb and palladium values ranging between 1 and 14 ppb. Perhaps farther east these values may improve.

Canadian Nickel Company Limited held four claims in the north half of Lot 8, Concession IV of Hartman Township in 1970. One diamond-drill hole (198.2 m) was sunk to test an airborne anomaly. Amphibolite, quartzite and graphitic schist in many places containing up to 20 percent pyrite and pyrrhotite were encountered; however, only trace amounts of chalcopyrite and sphalerite were observed in the metasediments and the claims were allowed to lapse.

This part of the map area is underlain by amphibolitic mafic metavolcanics correlated with the Southern Volcanic Belt which are intercalated with clastic metasediments of the Minnitaki Group, and is interpreted to represent a deep water depositional environment. In this environment graphite and sulphides

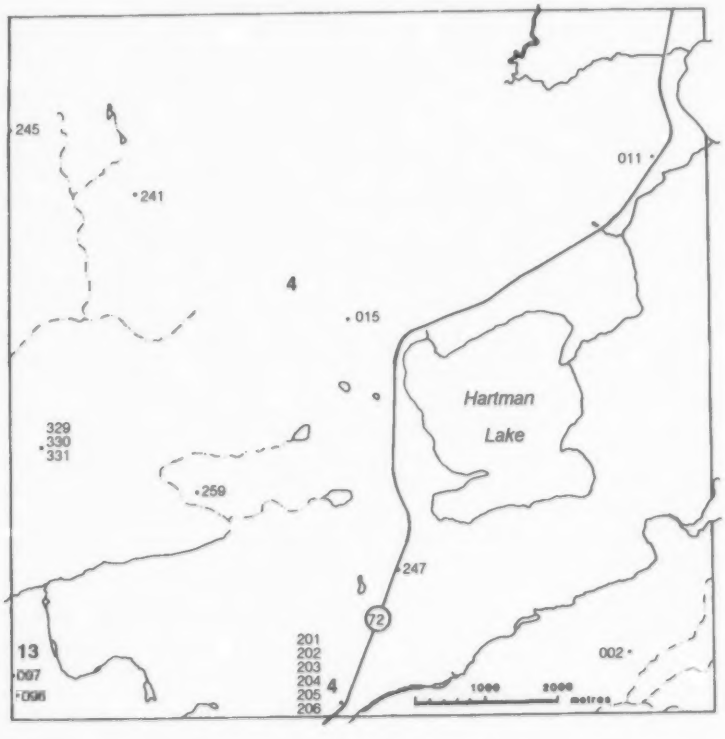


Figure 13. *Property and assay sample location map for Hartman Township.*

are interpreted to have accumulated during relatively quiescent intervals from exhalative volcanic sources. Commercial mineral deposits are generally scarce in this environment.

Canadian Nickel Company Limited held another group of 12 unpatented mining claims in the southern part of Laval Township south of Diamond Lake. Two diamond-drill holes (total 111.6 m) tested separate airborne anomalies approximately 1200 m apart. The western drill hole encountered mainly gabbro and mafic schist which could represent sheared gabbro with minor basalt and feldspar porphyry. Only trace amounts of sulphides, mainly pyrite and pyrrhotite were encountered and in the author's opinion the airborne conductor remains unexplained. The eastern drill hole encountered mostly massive and plagioclase porphyritic gabbro and schist. Again nil or trace amounts of sulphides were encountered and there is no satisfactory explanation for the airborne anomaly.

Traverses by members of the field crew found a limited amount of outcrop in this area. That which was found consists mainly of medium-grained gabbro and sheared gabbro. In the area of the westernmost drill hole, rusty gabbro containing less than 5 percent pyrite was sampled and analyzed returning 107 ppm copper, 12 ppm nickel, 17 ppb platinum, 14 ppb palladium and nil gold (sample 529, Figure 12). An airborne magnetic high and numerous east-northeast-striking airborne electromagnetic anomalies are coincident with the gabbro intrusion suggesting conductive material is present in the area and remains to be tested (Ontario Geological Survey 1987c). In this area gently dipping first stage deformational features are well preserved and it is distinctly possible the geophysics correspond to a gently dipping gabbro sheet.

Canadian Nickel Company Limited held a fourth claim group of 23 claims in Laval Township extending from Laval Lake northeast to the Laval–McAree Township line. Three diamond-drill holes (total 398.2 m) were sunk to test two widely spaced airborne electromagnetic anomalies. The southernmost drill hole was collared approximately 800 m northwest of Laval Lake (Figure 12) and encountered a variety of lithologies including mafic metavolcanic and metasedimentary schists, diorite dikes, felsic tuffs and feldspar porphyry dikes. Graphite and disseminated pyrite-pyrrhotite occur throughout the metasedimentary schists; however, the heaviest sulphide mineralization was encountered in the dacite tuff where up to 90 percent pyrrhotite and pyrite with trace amounts of chalcopyrite and sphalerite occur over narrow widths.

This diamond-drill hole is sited near the contact between the Neepawa and Minnitaki groups and in this area sulphide and oxide facies ironstones are common. Additionally sulphide mineralization may occur within the felsic metavoicanics as well as within interpillow material. Sample 170 (Figure 12, Table 7a) was collected by the field crew in this area and consisted of pyritic interpillow material which contained 1180 ppm copper, 6720 ppm zinc, 52 ppm nickel, 50 ppb gold and 3 ppm silver. These values indicate enrichment of base and precious metals has occurred in this environment and numerous electromagnetic anomalies detected by the Ontario Geological Survey sponsored airborne survey (Ontario Geological Survey 1987b, 1987c) remain untested in this area.

Canadian Nickel Company Limited diamond drilled another two holes (246.3 m) on this property approximately 800 m west of the Laval–McAree Township line and approximately 2.5 km northeast of the previously described hole. In both holes the predominant lithologies were wacke and related metasedimentary schist with minor felsic pyroclastic and mafic flow deposits. Graphite, pyrite and pyrrhotite occur as disseminations and in brecciated beds throughout both holes; however, only trace amounts of chalcopyrite and sphalerite were encountered.

Traverses carried out by members of the field crew indicate this general area is underlain by Minnitaki Group metasediments and mineralization within this group is most likely related to sulphide facies ironstones.

CANADIAN PACIFIC RAILWAY COMPANY (1956)

Two prospectors employed on behalf of the Canadian Pacific Railway Company (No. 5, Figure 12) staked 30 claims in Laval Township in 1956. These claims covered ground from south of Gardnar Lake to north of Laval Lake and the general geology of this area has been previously discussed under Billiton Metals Canada Incorporated and Canadian Nickel Company Limited.

The property was prospected mainly for copper-nickel mineralization and three pyrite-pyrrhotite zones containing only trace amounts of chalcopyrite were located. No further work was carried out and the claims were allowed to lapse.

ECLUND GOLD MINES LIMITED (1951–52)

In 1951–52, Eclund Gold Mines Limited (No. 6, Figure 12) held 24 unpatented mining claims in Laval Township. Stripping and trenching were carried out in a number of areas, however, results from this work were not reported. Eclund also diamond drilled six holes (total 269.9 m) in the southeast corner of the claim group. The first three diamond-drill holes (total 71 m) tested near surface mineralization in altered mafic metavolcanics. Up to 5.6 m (18.5 feet apparent width) of massive pyrite and pyrrhotite were encountered in silicified and what the author interprets as hematized basalts. No assay values are reported for these three holes and from the drill log descriptions and pattern of holes, the mineralization is interpreted by the author to be associated with hydrothermal alteration and localized in northeast-trending structures.

The next three diamond-drill holes were sunk approximately 60 to 120 m south of the previously described holes. These holes encountered wacke, silicified wacke, felsic tuff and graphitic breccias and schists. Sulphide mineralization was disseminated consisting mainly of pyrite with lesser amounts of chalcopyrite. Assay values from these holes returned nil gold and from trace to 0.08 ounce silver per ton over widths up to 1.3 m. These three holes were drilled in the general vicinity of the "exhalite" chert-sulphide horizon previously described under Billiton Metals Canada Incorporated, and the silver values reported by Eclund are generally in the same magnitude as those reported by Billiton from the "exhalite".

The Eclund Gold Mines Limited diamond drilling tested an area of geology at or near the contact of the Minnitaki Group and the Neepawa Group. Sulphide facies ironstones occur at several places along this contact to the northeast (Berger et al. 1989a, 1989b) and it is suggested Eclund's drilling intersected a sulphide facies ironstone at this interface. Although all diamond drilling along this contact has failed to intersect economic mineralization to date (Berger et al. 1989a, 1989b) there remains a lot of untested ground and the elevated silver values suggest more exploration is warranted.

FLOREGOLD RED LAKE MINES LIMITED (1950–52)

In 1950, Floregold Red Lake Mines Limited (No. 7, Figure 12) carried out ground magnetic and geology surveys over 12 unpatented mining claims east of Troutfly Lake. From these surveys two targets were selected and diamond drilled (two holes total 292.9 m). Both holes encountered intermixed mafic flows, felsic tuff and quartz-feldspar porphyry; however, no mention was made if sulphide mineralization of any type was encountered. Floregold Red Lake Mines Limited did no further work allowing the claims to lapse and the author infers nothing of economic interest was found.

Floregold's geophysical survey indicated that most of the western part of the property is magnetically flat and the eastern part of the property is generally more magnetic. This was interpreted to be due to metavolcanics underlying the western and metasediments underlying the eastern parts of the property with a magnetically complex contact. However, the diamond-drill hole in the east encountered only metavolcanics. Traverses in this area by members of the present field crew indicate the western part of this area is underlain by generally hornblende-phyric units of formation B of the Neepawa Group; whereas, the eastern part is underlain by units of formation A of the Neepawa Group. The areas of high magnetic relief are most likely either magnetic gabbroic dikes which occur in this area or magnetite-calcite alteration which occurs regionally in northeast-trending shear zones in several of the metavolcanic units.

GLATZ, ALEXANDER (1983–85)

Alexander Glatz (No. 8, Figure 12) staked four claims to cover a lead-zinc-silver showing in southwestern Laval Township in 1983. A report was completed summarizing the history of previous work and subsequently, ground magnetic and VLF-EM surveys were carried out on grid lines cut over the property. The lead-zinc-silver showing was previously explored by Hollinger Mines Limited (No. 11, Figure 12, *see* below) with generally discouraging results although silver assays up to 2.49 ounces silver per ton were returned from diamond-drill core. Grab samples from trenches previously explored by Hollinger returned from 0.44 to 12.02 ounces silver per ton and are associated with sulphide mineralization in rhyolitic tuffs and "volcano-genic" metasediments. Results from the ground surveys show a strong VLF-EM conductor and coincident high magnetism corresponds with the mineralization in the trench and indicates that this mineralization continues for over 600 m across the property.

The mineralization and geological environment is more thoroughly described under Hollinger Mines Limited (No. 11, Figure 12) which carried out a more extensive exploration program. No further work is reported for A. Glatz's property and the claims have since been cancelled as this land is now part of the Lola Lake Provincial Nature Reserve and can be explored only by an Exploratory Licence of Occupation (Government of Ontario 1985).

GRAHAM BOUSQUET GOLD MINES LIMITED (1950)

Fifteen unpatented mining claims covering two separate gold showings discovered by Alex Mosher in the Beartrack Lake area of Laval Township were optioned by Graham Bousquet Gold Mines Limited in 1950 (No. 9, Figure 12). An exploration program consisting of stripping, trenching and diamond drilling (366.5 m in 12 holes) was carried out on the property; however, results were not sufficiently encouraging and Graham Bousquet Gold Mines Limited allowed the option to expire. The gold showings have been staked several times since 1950; however, there has been no significant exploration since Graham Bousquet's work.

Diamond-drill logs and a report filed for assessment work credits by Graham Bousquet Gold Mines Limited indicate most work was carried out on the two gold showings (Assessment Files Research Office (AFRO), Toronto). Both showings are shear zone hosted and are located at either end of a metadiorite intrusion. Graham Bousquet personnel traced the northern showing for a distance of 61 m with an average width of 0.61 m. Here quartz veining, pyrite, arsenopyrite and sparse chalcopyrite were encountered but only grab samples containing arsenopyrite contained significant gold values of up to 0.30 ounce gold per ton.

The southern showing occurs in sheared metadiorite and was traced for 18 m with an average width of 0.6 m before becoming overburden covered. Trenching uncovered massive sulphide mineralization with a "fair amount" of sphalerite and galena and assay values of up to 0.75 ounce gold per ton and 5 to 7 percent zinc were reported.

Four X-ray diamond-drill holes (134.1 m) sunk under the northern showing encountered massive and silicified andesite, feldspar porphyry, diorite and chert with "augen flow structures" which the author interprets to be felsic spherulitic flows. Only sparse pyrite was encountered in the drill core and no assays higher than 0.01 ounce gold per ton were returned.

Four diamond-drill holes (total 92.1 m) sunk under the southern showing encountered diorite, andesite and silicified, pyritic zones. A 0.6 m section of quartz veins and highly silicified diorite with pyrite returned 0.09 ounce gold per ton when assayed from one of the diamond-drill holes and a 0.6 m section of pyritic and silicified "andesite" returned 0.27 ounce gold per ton from another hole approximately 23 m southwest of the first intersection. Other gold assays reported by Graham Bousquet Gold Mines Limited from this area ranged between trace and 0.01 ounce gold per ton.

Another four diamond-drill holes (140.3 m) tested other silicified or sheared zones located throughout the property. One diamond-drill hole returned 0.03 ounce gold per ton over 0.9 m from highly silicified and pyritic diorite, and results from the other holes ranged between trace and 0.01 ounce gold per ton.

During the present field season several traverses were carried out in the Beartrack Lake area and the two showings were located, examined and sampled. In addition, a detailed study of the northern showing was carried out and these results are presented by Chorlton (1987) and briefly described herein. In general the two gold showings are localized in third stage deformational shear zones and related extensional fractures and each showing exhibits different aspects of this style of gold mineralization.

The northern showing occurs near the north end of a metadiorite pluton and is localized within a shear zone trending 065 degrees. Here, mafic metavolcanic flows intruded by apophyses of the metadiorite are exposed in a number of old pits. A northerly trending 60 to 80 cm wide quartz vein containing 5 to 10 percent pyrite occurs in the westernmost pit but its strike extension could not be traced due to overburden cover. Two grab samples, one with pyrite (060, Figure 12) and one without (061, Figure 12), of the quartz vein were analyzed and returned 5 ppb and less than 2 ppb gold, respectively.

The eastern pits lack well-developed quartz veining. Instead the host mafic metavolcanics are pervasively silicified, carbonatized and chloritized containing from trace to 20 percent sulphides, mainly pyrite with very minor chalcopyrite. A grab sample (062, Figure 12) of the pyritic material returned 340 ppb gold, 245 ppm copper, and 750 ppm arsenic when assayed. Similar material was collected and analyzed by L.B. Chorlton (Ontario Geological Survey) and returned 1380 ppb gold. Another grab sample (063, Figure 12) of material containing less than 1 percent sulphides returned 3 ppb gold and 5 ppm arsenic when assayed.

It appears that at the northern showing gold is more likely to occur in sulphide-rich altered wall rock than in quartz veins or sulphide poor wall rock within the shear zone. Generally pervasive silicification and extensive sulphidization are confined to the shear zone; however, quartz veins are common outside as well as within the shear zone.

Traverses by the 1987 field crew in the area around the north showing located several additional east-northeast-trending shear zones within the metadiorite pluton, many of which are silicified. One area of potential economic interest occurs approximately 300 m west-southwest of the pits. Here extensive quartz veining, pervasive silicification, carbonatization and tourmalinization with up to 10 percent pyrite occurs in massive to sheared quartz diorite (Photo 9). Samples collected by the author returned less than 2 ppb gold, up to 18 ppm arsenic and up to 525 ppm tungsten (288 to 289A, Figure 12). A sample of similar material collected by L.B. Chorlton (Ontario Geological Survey) returned 230 ppb gold when assayed. Scheelite was identified by means of an ultraviolet lamp in sample 289A (Figure 12).

Where the metadiorite is exposed along the shoreline of Beartrack Lake, two silicified shear zones and several quartz veins were observed. The silicified zones are characteristically light grey with red brown to brown carbonate spots and white calcite-quartz veinlets. Disseminated sulphides are commonly highly oxidized and rarely comprise more than 5 percent of the rock. Two grab samples (049, 053, Figure 12) from these silicified zones returned 2 ppb and 40 ppb gold. A grab sample from a quartz-tourmaline vein intruding the metadiorite outside of these zones returned 2 ppb gold (052, Figure 12).

The southern gold showing explored by Graham Bousquet Gold Mines Limited is situated approximately 275 m south of Beartrack Lake. Here a trench approximately 15 m by 2 m by 0.6 m deep and the collars of three X-ray diamond-drill holes were located by the survey crew. Gold mineralization occurs in a shear zone trending 025 degrees and accompanies pervasive silicification, sericitization and sulphidization which has replaced the host metadiorite. Unlike other gold occurrences in the map area, sulphides are abundant here comprising up to 75 percent of the rock. Pyrite is most abundant with subordinate amounts of sphalerite and chalcopyrite (Photo 10). Although arsenopyrite was not identified in the trench a strong arsenic smell was detected on freshly broken rock surfaces. Galena was reported by Gra-

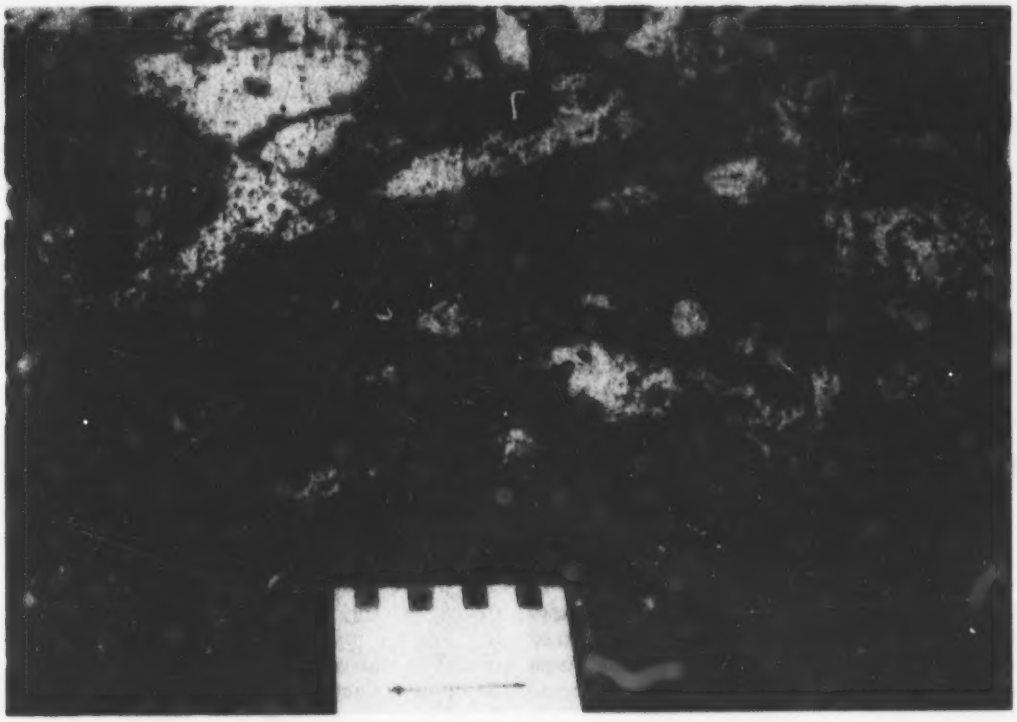


Photo 9. *Quartz (QTZ) and tourmaline (TOUR) breccia in quartz diorite (QTZ DIORITE) west of Beartrack Lake. Samples of this material contain up to 230 ppb gold and 525 ppm tungsten.*

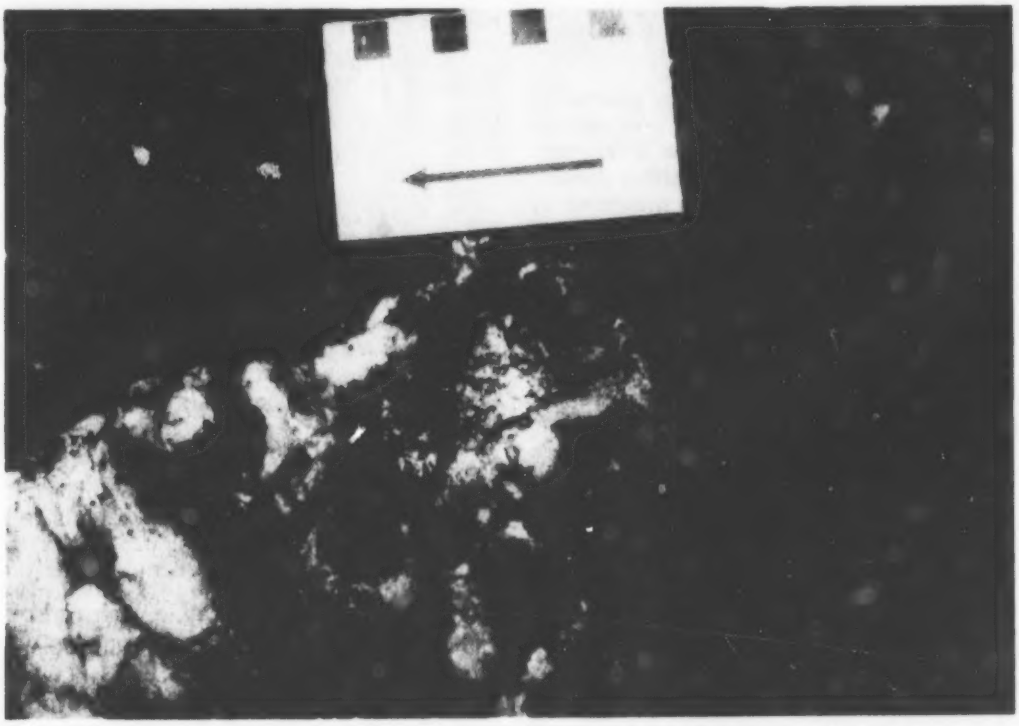


Photo 10. *Pyrite (PY) in quartz vein (QTZ) located in westernmost trench of Graham Bousquet No. 1 showing; west of Beartrack Lake.*

ham Bousquet personnel; however, none was observed by the author.

Three grab samples were collected from the trench by the author and assayed. A sample (031, Figure 12) of siliceous and sericitic schist containing 10 percent cubic pyrite and 5 percent magnetite octahedra returned 8520 ppb gold (0.25 ounce gold per ton), 5 ppm silver (0.14 ounce silver per ton) and 400 ppm arsenic when assayed. Sample 032 (Figure 11) was composed of approximately 50 to 75 percent sulphides in a silica-tourmaline-chlorite-rich matrix and returned 550 ppm copper, 50 ppm lead, 2860 ppm zinc, 1000 ppm arsenic, 31 670 ppb gold (0.92 ounce gold per ton) and 6 ppm silver (0.17 ounce silver per ton). Sample 034 (Figure 12) which is most abundant in the trench of a sericitic schist with minor silica and up to 30 percent pyrite returned 300 ppb gold, 950 ppm zinc and 350 ppm arsenic. L.B. Chorlton (Ontario Geological Survey, personal communication, 1988) reported that up to 0.3 ounce gold per ton was obtained from samples she collected at the trench. A fourth sample (035, Figure 12) of a chalcopyrite-bearing quartz vein approximately 15 m east of the trench returned 70 ppb gold and 115 ppm copper when assayed.

These assay values indicate gold is strongly correlated with arsenic and to a lesser extent with zinc. Highly silicified and sulphidized rocks tend to carry better gold values than sericitic or weakly altered rocks. The shear zone appears to have acted as a conduit focussing the mineralized fluids.

Traverses around the showing indicate widespread tourmalinization has affected all rocks in the area; most particularly tourmaline replaces original pore space in mafic fragmental rocks west of the showing. Traverses northeast of the showing indicate other northeasterly trending shear zones cutting the metadiorite are auriferous. Sample 220 (Figure 12) was collected from a 25 cm wide shear zone containing 10 to 20 percent pyrite, chalcopyrite and magnetite in weakly silicified and biotitic diorite. When assayed this rock returned 1400 ppb gold, 4840 ppm copper and 905 ppm zinc. Approximately 50 m to the west a 1 m wide shear zone composed of talc-chlorite schist with carbonate, minor silica, pyrite, chalcopyrite and malachite was sampled and assayed (222, Figure 12). Results include 130 ppb gold, 3070 ppm copper and 570 ppm zinc.

In conclusion, the two gold showings explored by Graham Bousquet Gold Mines are localized in third stage deformation shear zones and related extensional fractures within or near the contacts of a metadiorite pluton. Economic gold values up to 0.92 ounce gold per ton were obtained from the southern showing and indications of gold in previously unexplored shear zones indicates this entire area warrants careful and extensive exploration.

GRAND CHIBOUGAMAU MINES LIMITED (1951)

Grand Chibougamau Mines Limited (No. 10, Figure 12) acquired 20 unpatented mining claims immediately east of Troutfly Lake in Laval Township in 1951. A geological survey failed to identify any strongly mineralized zones; no further work was carried out and the claims were allowed to lapse.

Traverses carried out by the 1987 survey crew indicate this area is underlain by Neepawa Group metavolcanics in contact with Minnitaki Group metasediments. The strike extension of the metagabbro intrusion that hosts the Mistango gold showing (*see* Mistango Consolidated Resources Limited) underlies this area and although pervasive silicification and quartz-pyrite veins characteristic of the showing were not observed, much of the intrusion is poorly exposed here. Several northeast-trending shear zones occur in this area, many of which contain pervasive calcite-iron carbonate alteration. The most prominent of these zones occurs along the metavolcanic-metasedimentary contact.

HOLLINGER MINES LIMITED (1977–78)

In 1977, Hollinger Mines Limited (No. 11, Figure 12) in joint venture agreement with Amax Exploration Incorporated optioned 33 unpatented mining claims in southwestern Laval Township and southeastern Brownridge Township from Alex Kozowy of Dryden, Ontario. The claims were staked to cover a lead-zinc-silver showing discovered by A. Kozowy and to cover airborne electromagnetic anomalies previously detected and for which reports were filed for assessment work credits by Pennarroya Canada Limitee (*see* below).

Hollinger Mines Limited personnel carried out a ground VLF-EM survey over four claims centred on the lead-zinc-silver showing. This was followed by ground magnetic, horizontal loop electromagnetic and geological surveys over the entire claim group, and based on the results, five diamond-drill holes, four of which were sunk in Laval Township (total 483.5 m), were completed. Results from the diamond drilling were not sufficiently encouraging and the option was terminated.

The lead-zinc-silver showing is described by Bateman (1977) as consisting of up to 10 percent fine-grained pyrite, galena, sphalerite, chalcopyrite and pyrrhotite within "volcanogenic tuffs or sediments" near the contacts with felsic fragmental rocks. The mineralization is exposed in a 4.5 m by 1.5 m pit and has been extensively sampled. Assays reported by A. Glatz (*see* above) and attributed by him to Hollinger Mines Limited's sampling indicate silver values in the range 0.44 ounce silver per ton to 12.02 ounces silver per ton were obtained from the pit; however, values for other elements were not reported. Results from the diamond drilling which were obtained at the Drill Core Library in Kenora, Ontario, and are not available at AFRO in Toronto indicate subsurface miner-

alization is erratic and confined to veinlets cutting felsic metavolcanic flows and fragmentals. Lead values up to 9850 ppm (0.985 percent) over 0.6 m accompanied by silver values up to 2.49 ounces silver per ton were reported from two drill holes sunk under the showing along with zinc values up to 7840 ppm, up to 420 ppm copper and up to 0.005 ounce gold per ton.

Two other diamond-drill holes tested geophysical targets elsewhere on the property in Laval Township and returned assays no higher than 1560 ppm copper, 1530 ppm zinc, 200 ppm lead, 1 ppm silver and 0.005 ounce gold per ton from graphitic ironstones and schists.

The lead-zinc-silver showing was not located by the present survey crew although two traverses were carried out in the general area. Representative samples of the diamond-drill core are stored for all five holes at the Kenora Drill Core Library and these were examined with selected samples submitted for thin sections and whole rock analysis. From these data the author agrees with the general geology of the property as described by Bateman (1977); however, at least some of the felsic units described in diamond-drill logs are silicified mafic flows rather than felsic metavolcanics. Further, felsic "agglomerate" units and some felsic fragmentals described in the drill logs are actually spherulitic rhyolite and dacite flows.

The area north and east of the showing was traversed by the author and here metavolcanic units of formation A of the Neepawa Group were observed. Pillowed, massive and rarely pillow breccia units predominate; however, narrow units (10 to 50 m) of spherulitic and flow banded rhyolite are present and one of these units forms the eastern strike extension of the showing. Pervasive carbonate alteration accompanied by pyrite, tourmaline and quartz veining occurs along the contact of the spherulitic flows of this unit and mafic metavolcanics at one place and two grab samples (400, 401, Figure 12) were collected and assayed with discouraging results (Table 2a). One sample (280, Figure 12) of graphitic schist was picked from one of the diamond-drill holes stored in Kenora and returned only low values (Table 2a).

It appears that potentially economic mineralization is preferentially sited within the felsic metavolcanic units and future exploration should concentrate on locating them. Electromagnetic anomalies in this area are generally caused by graphitic and pyritic ironstone horizons (Bateman 1978). Although these horizons are not primary base metal targets, they cannot be totally ignored as they are rarely enriched in copper and zinc. It appears that the gold potential of this area has not been adequately explored.

JALNA RESOURCES LIMITED (1983–84)

In 1983, Jalna Resources Limited (No. 12, Figure 12) held two large blocks covering parts of Laval, Zealand and Brownridge townships. The Beartrack Lake property consisted of 132 unpatented mining claims covering the western part of Beartrack Lake and extending southwest beyond Rafter Lake. The Laval–Lola Lake property consisted of 123 unpatented mining claims extending west from Laval Lake to Lola Lake and well into Zealand Township. Each claim group and surrounding area was explored by reconnaissance scale (1:20 000) geological and geochemical traverses; however, no detailed work was carried out and all claims were allowed to lapse. From the reconnaissance work elevated gold values were found to be erratically distributed within the map area with maximum values of 32 ppb gold from the Diamond Lake area and 58 ppb gold from the Troutfly Lake area. Neither of these values was considered sufficiently interesting to warrant further exploration.

KAKISH, J. (1971)

In 1971, J. Kakish (No. 13, Figure 13) filed a work report but no survey plans for a ground magnetic survey on Lot 12, Concession I of Hartman Township which includes the former patented mining claim SV 116.

Most of Lot 12 is overburden covered, however, outcrop belonging to the Southern Volcanic Belt is exposed along the southeastern part. The rocks are composed of massive to variolitic basalt with minor pillow breccia which have been intruded by feldspar porphyry dikes. The Hartman Lake Stock is interpreted from aeromagnetic data (Ontario Geological Survey 1987c) to underlie the eastern half of Lot 12.

Pyritic, pyrrhotitic and ankeritic basalts usually accompanied by feldspar porphyry dikes occur within claim SV 116 and along the Hartman–Zealand Township line. Two grab samples (096, 097, Figure 13, Table 2b) were collected by the field party personnel and assay values of less than 2 ppb gold, less than 2 ppm silver, 9 to 14 ppb platinum and 6 to 14 ppb palladium were returned.

MISTANGO CONSOLIDATED RESOURCES LIMITED (1982–)

As of December 1987, Mistango Consolidated Resources Limited (No. 14, Figure 12) held 92 unpatented mining claims in Laval Township. The claims cover either portions or all of ground previously explored by Amant Gold Mines Limited, Billiton Metals Canada Incorporated, Calder Bousquet Gold Mines Limited, Canadian Pacific Railway Company, Eclund Gold Mines Limited and Selco Mining Corporation Limited. Gold is the principal economic commodity of interest on the property and Mistango has concentrated exploration on the southern part of Troutfly Lake where auriferous quartz veins are hosted in silicified, carbonatized and pyritized metagabbro-altered gabbro intrusions.

In 1982, Mistango Consolidated Resources Limited acquired 20 unpatented mining claims at the south end of Troutfly Lake to cover the "Calder

Bousquet Prospect" described by Beard and Garrett (1976) (*see* above). A ground magnetic survey was carried out and follow-up staking expanded the property to its present 92 claims. Mistango then had the entire claim group explored by means of airborne VLF-EM and magnetometer surveys. Billiton Metals Canada Incorporated optioned the property in 1984, carried out extensive surface exploration and subsequently returned the property to Mistango (*see* above). In 1986, Mistango completed an undisclosed amount of diamond drilling and reported one drill hole intersection of 0.49 ounce gold per ton over 1.8 m (Northern Miner, February 2, 1987, p.10). In August 1987, Mistango started a second diamond drilling program to test the main zone mineralization and a second, recently discovered, southwest zone (Chorlton 1987). As of September 1987, approximately 473 m of diamond drilling in five holes were completed with an additional five to six holes planned (J. Parker, Kenora Resident Geologist's office, personal communication, 1987). Diamond-drill logs and assay results were not available at the time of writing.

The main zone gold mineralization (Figure 14a) is thought by the author to occur at or near the original gold discovery reported by Calder Bousquet Gold Mines Limited (No. 3, Figure 12, *see* above). Here gold commonly occurs in quartz-pyrite-galena veins hosted in fractured, pyritized, carbonatized, albitized and silicified metadiorite (Photo 11). The quartz veins strike mainly 260 degrees, dip moderately to the north and are localized in the hinge zones of third stage, southwest-plunging folds (Chorlton 1987). First stage deformational features are well preserved in this area and gentle to moderate dips on foliation and lithologies are common (Figure 14a). The attitude of the host metadiorite is controlled by the first stage deformation and is generally subhorizontal to gently southeast dipping and generally tabular in shape.

An extension to the main zone mineralization occurs approximately 100 m to the southwest (Figure 14b) and here contacts of the altered gabbro were observed to be chilled against mafic metavolcanics and metagabbro (Chorlton 1987). This indicates that there is a complex history of intrusion at this showing. The metagabbro continues along the southern edge of the extension zone through an island at the south end of Troutfly Lake where old trenches, sunk by Amant Gold Mines Limited, expose several east-northeast-trending quartz carbonate veins. The veins are within a silica-carbonate alteration halo and contain pyrite, galena and trace amounts of scheelite.

The recently discovered southwest zone on the Mistango property occurs in a similar geological environment as the main zone. Pyrite-galena-bearing quartz veins are sited in fractured and altered gabbro-metagabbro. Alteration consists mainly of pyritization accompanied by pervasive magnetite and carbonate and the gently dipping first stage deformation features are well preserved (Figure 14b; Chorlton 1987).

A representative sample from the main zone collected by the present field party returned less than 2 ppb gold, less than 2 ppm silver and 5.5 ppm arsenic (137, Figure 12). A number of samples (318 to 324, Figure 12) collected from the old Amant trenches returned no assay values higher than 8 ppb gold, less than 2 ppm silver, 60 ppm copper and 800 ppm lead. Chorlton (1987) collected several samples from the main and southwest zones and assay values up to 29 ppb gold were returned. These values indicate on-surface gold tenor is generally low with higher grades erratically distributed in quartz veins.

A distinctive variolitic unit occurs along the northern contact of the main zone metadiorite and the southwest zone metadiorite-metagabbro. This unit is characterized by felsic varioles up to 5 cm in diameter in a mafic groundmass that grade into felsic varioles (1 to 5 mm) in a black rhyolitic groundmass and at several places coalesced and broken varioles are present giving a fragmental appearance to the rock.

This unit occurs at several places southwest of the main zone and serves as a reliable marker horizon. Metadiorite-metagabbro intrusions always occur in close proximity.

The "altered gabbro" (map unit 5f, Map 2534 *in* back pocket) hosting the main zone is a light grey, feldspathic rock that is generally medium grained and equigranular where it is unaltered. Commonly, however, the metadiorite is pink to buff due to pervasive iron carbonate alteration, albitization, silicification and pyritization. Where this occurs, as at the Goldlund Mine (10 km northeast) and at the main zone of the Mistango showing, the term "granodiorite" has been applied to the rock by previous workers (cf. Page 1984).

The metagabbro accompanying the "altered gabbro" occurs on the island in southern Troutfly Lake. It is a dark green, medium-grained to porphyritic rock. Centimetre-sized hornblende and/or plagioclase phenocrysts are common and may be abundant (up to 50 percent) in some places. The intrusion is generally magnetic and can, therefore, be traced by geophysical methods.

Both the metagabbro and "altered gabbro" occur separately and together elsewhere on the Mistango property. The "altered gabbro" always occurs in close proximity to variolites; however, metagabbros are more widely distributed. Many of the magnetic anomalies detected by ground and airborne surveys can be attributed to metagabbros as can numerous topographic ridges southwest of the Mistango showing. Further, the "altered gabbro"-metagabbro sheets are known to extend northeast of the map area in McAree Township and possibly are continuous with the "altered gabbro" sheets hosting the Goldlund deposit in Echo Township (Berger et al. 1989a, 1989b; Chorlton 1987).

Gold may occur wherever third stage folding or flexing has fractured these intrusions allowing quartz

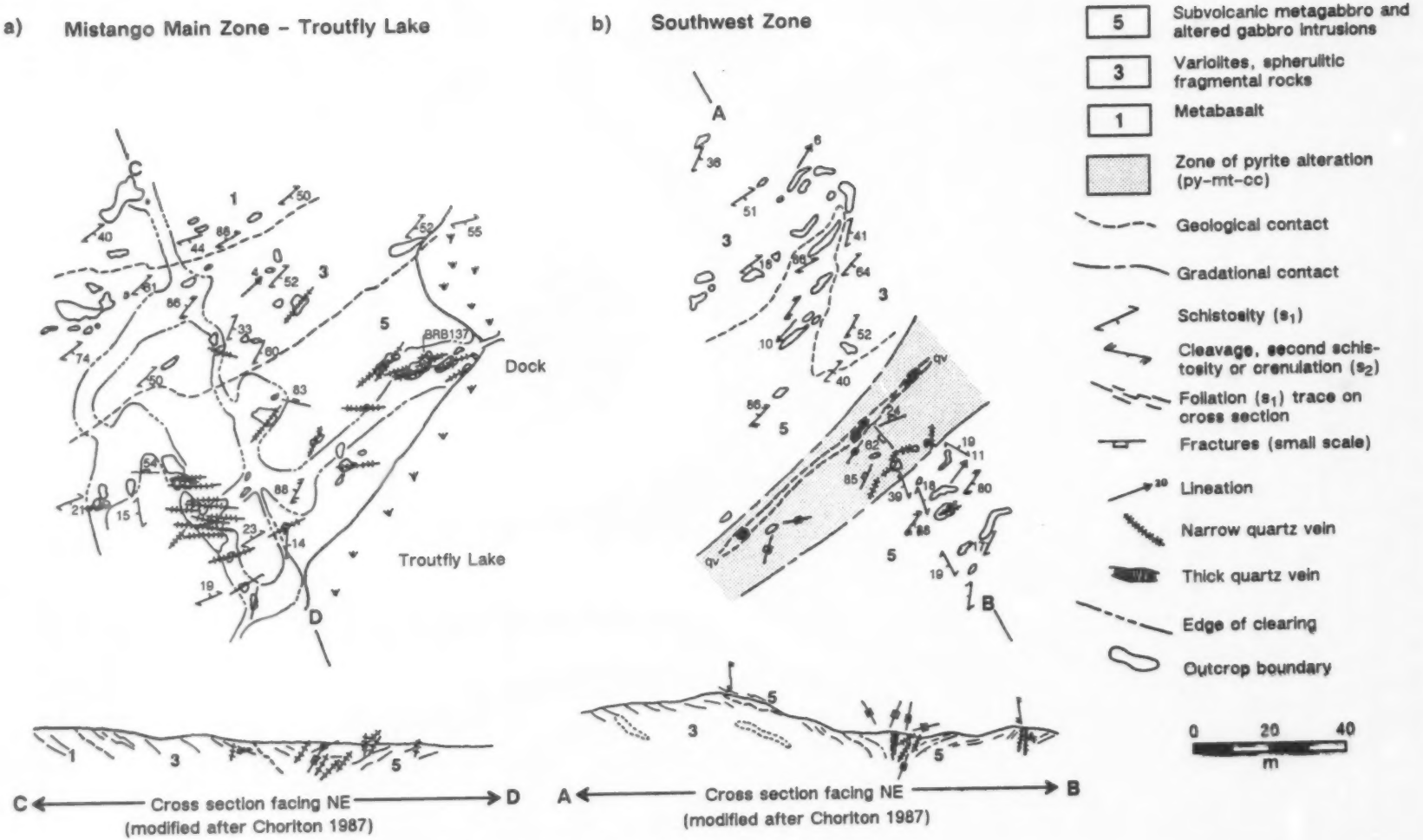


Figure 14. *Geological sketch maps—Mistango showings, Troutfly Lake, Laval Township.*

Photo 11. *Quartz veining in altered gabbro at Mistango Main showing, southwest shore of Troutfly Lake, Laval Township. (Pencil is 15 cm long.)*

veining and alteration to develop. Although gold mineralization is localized in third stage deformational features, the attitude of the "altered gabbro"-metagabbro sheets is controlled by the first stage deformation and gentle to moderate dips should be expected in any type of subsurface exploration.

MORTON, C., 1969

In 1969, Coleman Morton (No. 15, Figure 12) commissioned an airborne radiometric survey for a group of claims covering the eastern part of Laval Township and the western part of McAree Township. The claims covered part of the Sandybeach Lake Stock and the granitic pegmatites developed along its northern contact. The airborne survey failed to detect any anomalous radioactivity and the claims were subsequently allowed to lapse.

PENARROYA CANADA LIMITEE, 1965

The central and western parts of Laval Township along with parts of Brownridge and Zealand townships were surveyed magnetically and electromagnetically by aircraft by Penarroya Canada Limitee in 1965 (No. 16, Figure 12). An undisclosed number of mining claims were staked over selected anomalies and the author assumes follow-up ground work was carried out although there are no reports on file at the Assessment Files Research Office in Kenora or Toronto. Bateman (1977) concluded that 200 feet (60 m) of old AX diamond-drill core found on Hollinger Mines Limited property (No. 11, Figure 12) was drilled by Penarroya Canada Limitee. This core was examined and sampled by Bateman (1977) and he concluded that no economic mineralization was present.

As best as the author can determine, most of the electromagnetic anomalies detected by Penarroya Canada Limitee's survey in Laval Township have been reproduced by the Ontario Geological Survey, Dryden area, airborne electromagnetic and magnetic surveys (Ontario Geological Survey 1987a-f).

SELCO MINING CORPORATION LIMITED (1977)

In 1977, Selco Mining Corporation Limited (No. 17, Figure 12) held several separate groups of mining claims in Laval Township in their search for base metals. Grid lines were cut over portions of these claim groups and ground magnetic and horizontal loop electromagnetic (HLEM) surveys were carried out. From these surveys, targets were selected for diamond drill testing. Only one diamond-drill log was submitted for assessment work credits and this was for a drill hole collared approximately 1300 m east of the south end of Rafter Lake. Here, andesitic flows and flow breccia were intercalated with siliceous and sericitic felsic tuff and lapilli tuff of the Neepawa Group and intruded by a quartz-feldspar porphyry dike. Up to 50 percent

pyrrhotite and pyrite with trace chalcopyrite was encountered within the felsic tuff and andesitic flow breccia. Low metal values including up to 0.02 percent copper, 0.18 percent zinc, 0.002 ounce gold per ton and 0.03 ounce silver per ton were returned from assayed samples.

Traverses carried out by the 1987 survey crew in this area indicate the metavolcanics are units within formation A of the Neepawa Group. For the most part the metavolcanics are composed of amphibolitic massive and pillowed mafic flows with rare pillow breccia units. At one location rusty and pyritic pillow rims 1 cm thick were observed and a sample (092, Figure 12) of this material returned 78 ppm copper, 125 ppm zinc, 46 ppm nickel and 4 ppb gold.

This pillowed sequence is overlain by a variolitic-spherulitic unit composed of individual flows 1 to 3 m thick. Each flow contains a massive to sparsely spherulitic base and a densely variolitic to massive felsic (dacitic) top which rarely contains iron carbonate and pyrite. This unit is interpreted by the author to be the strike extension of the felsic tuffs intersected in Selco's drill hole.

Members of the 1987 field season survey crew discovered abandoned core from two diamond-drill holes south of Diamond Lake in Laval Township. From assessment reports and OGS Preliminary Map P.2334 (Speed and Maxwell 1980b), the author attributes this work to Selco Mining Corporation Limited.

The predominant rock type encountered in both drill holes was a fine-grained, light grey, biotitic and muscovitic wacke. Minor felsic tuff interbeds are represented by more sericitic and siliceous interbeds and these layers contain pyrite, pyrrhotite and small amounts of graphite. The easternmost hole encountered approximately 15 m of graphitic and pyritic schist within the wacke. A composite sample of this material returned 136 ppm copper, 740 ppm zinc and less than 1 ppb gold when assayed (295, Figure 12). In the westernmost hole the wacke and felsic tuff passed down hole into a massive, equigranular gabbro which was observed in outcrop to the northeast. Approximately 30 m of core was recovered from this hole and transported to the Drill Core Library in Kenora, Ontario, where it is now available for inspection.

Selco also held mining claims on the north shore of Rafter Lake and southeast of Gardnar Lake; however, economic mineralization was not encountered on any of the claim groups and Selco allowed all claims to lapse.

TARBUSH LODE MINING LIMITED (1980–84)

In 1980, Tarbush Lode Mining Limited (No. 18, Figure 12) staked three mining claims along the eastern boundary of Laval Township contiguous with a much larger claim group in McAree Township. Most of Tarbush's exploration for gold mineralization was carried out in McAree Township and has been summarized by Berger (1989). The three mining claims in Laval Township were surveyed by ground magnetometer; however, nothing else was done and the claims have been allowed to lapse.

RECOMMENDATIONS TO PROSPECTORS

Gold is the most important economic mineral in the map area and the potential for discovering new mineralization is good. To a lesser extent there is potential for discovery of base metal mineralization.

Three gold showings occur in the area and, at each, mineralization is localized in third stage deformational features. Chorlton (1987) has determined that there are two styles of mineralization present and that each style is predominant in a specific geographic area or belt within the map area.

One style of gold mineralization occurs on the Mistango Consolidated Resources Limited property where auriferous quartz veins accompanied by pervasive carbonatization, silicification, albitization and pyritization occur in the hinge zones of third stage deformation folds within "altered gabbro". This style of mineralization resulted from the rotation, flexion and resultant fracturing of structurally competent bodies and is dominant within a northeast-trending belt extending from south of Troutfly Lake through the Goldlund Mine No. 1 ore zone (Chorlton 1987). Although any deformed structurally competent body is a potential target, to date gold has been discovered only in the "altered gabbro"-metagabbro intrusions. Extensive shearing of the host rock is not a prerequisite for this style of mineralization; however, shear zones within this belt cannot be ignored as gold does occur within northeast-trending shears to the east in McAree and MacFie townships (Berger et al. 1989a, 1989b).

The second major style of gold mineralization is represented by the two gold showings in the Beartrack Lake area (*see* Graham Bousquet Gold Mines Limited above) where mineralization is localized predominantly in third stage deformational shear zones and related extensional fractures. In this area a number of northeast- and east-northeast-trending shear zones within or close to a subvolcanic "altered gabbro" pluton are pervasively silicified containing from trace up to 75 percent sulphides and from less than 2 ppb gold up to 0.92 ounce gold per ton. The entire area within and around the "altered gabbro" has high potential for gold mineralization.

This style of mineralization extends southwest of Beartrack Lake and approximately 1200 m west of Gardnar Lake. Northeast-trending shear zones in felsic schists are pyritic (up to 20 percent) and contain elevated gold values from 9 to 40 ppb gold (074, 264, 265, Figure 12). L.B. Chorlton (Ontario Geological Survey, personal communication, 1988) reported up to 57 ppm tungsten from the same area

and these values suggest further exploration is warranted.

The area southeast of the Hartman Lake Stock in Hartman Township warrants exploration. Units of the Southern Volcanic Belt are extensively sheared and in places are pervasively carbonate altered, injected with quartz stringers and contain disseminated pyrite and chalcopyrite. One sample of this material (002, Figure 13) returned only 110 ppm copper and less than 2 ppb gold; however, the sampled area is part of a regional shear zone system which is known to host gold mineralization to the northeast (Berger et al. 1989a, 1989b).

Within the map area lead-zinc-silver mineralization occurs west of Diamond Lake within formation A of the Neepawa Group and is spatially associated with massive to spherulitic felsic flows and related fragmental rocks. Spherulitic rocks occur along several horizons between the lead-zinc-silver showing and Troutfly Lake and everywhere are accompanied by at least trace amounts of pyrite and chalcopyrite. Base and precious metals may occur elsewhere along these horizons and numerous airborne electromagnetic anomalies (Ontario Geological Survey 1987a-f) indicate there are a number of targets to be tested in this area.

To a lesser extent base metal mineralization occurs along or near the contact between the Neepawa and Minnitaki groups. Minor amounts of copper, zinc and silver occur within graphitic schists and sulphide facies ironstones along the contact and interbedded with wackes of the Minnitaki Group. As well, copper, zinc, silver and elevated gold values occur within interpillow sulphides and in sheared felsic tuffs and schists of the Neepawa Group in this general area. Future exploration of this area could be successfully integrated with exploration along spherulitic horizons as both types of targets are in close proximity.

Another potential base metal target occurs near the southern boundary of Hartman Township. Massive pyrite and pyrrhotite exposed along Highway 72 is hosted in mafic metavolcanic flows of the Southern Volcanic Belt and appears to be localized along a northeast-trending shear zone. Although sampling and previous diamond drilling by Canadian Nickel Company Limited (No. 4, Figure 13) failed to encounter economic mineralization, airborne electromagnetic anomalies (Ontario Geological Survey 1987a-f) to the northeast and southwest indicate there are untested targets along strike.

The white granitic pegmatite prevalent along the northern contact of the Sandybeach Lake Stock and intrusive into the Minnitaki Group metasediments at several locations is a potential host for industrial minerals and rare earth mineralization. The pegmatite contains muscovite and biotite with accessory garnet, tourmaline and sillimanite and as such is peraluminous. Redden (in preparation) has examined the suitability of the white pegmatite for crushed and decorative stone with generally positive results. A muscovite concentrate prepared from a sample collected along Highway 72 in Laval Township returned 1420 ppm lithium and 171 ppm gallium (Redden, in preparation) and indicates these pegmatites are enriched in rare earth elements compared to barren pegmatites (D. Janes, Sioux Lookout Resident Geologist's office, personal communication, 1987). During the field season two samples of the pegmatite were submitted for assay (241, 245, Figure 13). Sample 245 (Figure 13) collected from a 15 cm wide pegmatite dike intruding garnetiferous wacke returned 115 ppm tin, 152 ppm tantalum, 74 ppm niobium and 65 ppm beryllium and indicates exploration for these metals is warranted. F. Breaks (Ontario Geological Survey, personal communication, 1988) indicates the pegmatite field in the map area is the extension of the lithium-bearing pegmatite field north of Dryden, Ontario, approximately 10 km to the west.

Finally, there is commercial exploitation of a large sand and gravel deposit along Highway 72 in Hartman Township. This deposit is part of the Hartman terminal moraine and consists of glacial outwash deposits (Zoltai 1961). There is potential for exploitation of additional deposits especially along the Hartman–MacFie Township line, approximately 1500 m south of Sandybeach Lake.

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